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*Entrepreneurship, technology and change: a review and proposal
for an interpretative framework*

by

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Entrepreneurship, technology and change: a review and proposal for an interpretative framework

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Abstract

The objective of this article is to analyze the relationship between entrepreneurship and change in technological domains, with the focus on possible causal relations in both directions. It aims at investigating how technological changes generate opportunities that entrepreneurs or entrepreneurial organizations can properly exploit, and shedding light on how entrepreneurial behavior can be a promoter of change in both technology-intensive and technology-adopting businesses. Finally, we contribute to the literature on technology entrepreneurship by suggesting an explicit theoretical relationship between innovation dynamics (or techniques) and the entrepreneurial behavior of firms.

Keywords: technology entrepreneurship, technological change, knowledge-base innovation, entrepreneurial orientation.

1. Introduction

The objective of the present chapter is to analyze the relationship between entrepreneurship and change in technological domains, with the focus on possible causal relations in both directions. It aims at investigating how technological changes generate opportunities that entrepreneurs or entrepreneurial organizations can properly exploit, and shedding light on how entrepreneurial behavior can be a promoter of change in both technology-intensive and technology-adopting businesses.

Over the last 15 years we have been assisting (and keep on assisting, even nowadays) a spectacular amount of changes generated by science and technology. Technology is commonly numbered among the top drivers of a strong entrepreneurial ‘renaissance’ (Dosi, 1982; Arend, 1999), in particular thanks to its pervasive role, to its dramatic and irreversible development, and to the fact that recent technological changes (especially in ICT, green tech, biotechnology and life sciences) are generating opportunities that may be effectively developed by entrepreneurial firms (Stam and Garnsey, 2007).

The starting point for our meditation on this topic is the perception that ‘entrepreneurship is about change’ (Audrestch, 2002); among all change enablers, we focus on technology because it is inherently pervasive and generates opportunities that can be caught by an entrepreneurial organization.

At the same time entrepreneurial posture may be able to generate significant push in technological advancement and innovation.

We approach these topics along two main perspectives: on the one hand we try to go beyond a pure focus on the radical, architectural, and product-related technical change, since we analyze both technology producers and technology users (i.e. individuals or firms capable of exploiting technologies as a tool for change). This is somewhat novel in the literature on technology entrepreneurship. On the other, we consider how the link between technological change and entrepreneurship varies along the firm’s life cycle; in particular what is the role of entrepreneurship in large and mature businesses? We thus encompass the scientific advancement that has overcome the Schumpeterian dichotomy of incumbent vs. new firms in innovative regimes.

The goal of this chapter is to formulate a conceptual map, based on a literature review, for homogenous handling of the book chapters. We also intend to provide a reconciliation of disciplines such as strategic management, entrepreneurship, technology management and economics of technological change in the context of recent research progresses. Finally we aim to suggest room for future research.

We based our analysis on a literature survey carried out on sixty journals included in the ABS ranking,¹ that are in the areas of entrepreneurship, strategic management, and innovation. Through this survey we selected a number of papers which helped us to identify in the extant literature on entrepreneurship and technological change recent trends and new emerging concepts. The survey was conducted as suggested by Schildt et al. (2006): for the last three years, each issue and volume has been examined, while a second analysis has been performed on the last ten years, based on indexed research of papers containing the words ‘technologic(al) change’ and ‘entrepreneur(ship/ial)’ in the title.

This resulted in more than 600 paper titles; given the nature of our research interest, we then only selected papers (both theoretical and empirical) based on the firm- or industry-level perspective and practically no individual level related papers have been included. A deeper analysis of titles enabled the identification of more than 100 contributions which were considered as relevant if at least one of the following conditions was verified: (a) the paper described entrepreneurship, or theorized on it, within the technological domain; (b) the paper described technological changes in an entrepreneurial regime; (c) the paper suggested causality links between entrepreneurship and technological change, and/or vice versa.

The chapter is organized as follows: in Section 2 we introduce evidence and debates regarding the definition of entrepreneurship; Section 3 introduces the dimensions and antecedents of technological change, providing a knowledge-based perspective that is functional to illustrate a bidirectional relationship with entrepreneurship (shown in Section 4). Section 5 discusses the role of innovation dynamics at the crossroads between entrepreneurship and technological change, deriving a conceptual map for the understanding of their mutual causality relation. Section 6 summarizes and concludes.

2. Entrepreneurship: toward a knowledge-based definition

The major issue in entrepreneurship research is the inability to create a solid and shared conceptualization of entrepreneurship. Davidsson et al. (2002) and Fayolle (2007) synthesize effectively the research on entrepreneurship, in particular with respect to definitional issues; the most prevalent and convincing perspectives on entrepreneurship they recall introduce the perception of opportunities and the subsequent generation of new ideas in the market through a new organization or new economic activity. Fayolle (2007) suggests entrepreneurship as a dialogic process between individuals (or firms) and their context, which results in value creation. We find the process approach particularly meaningful since it suggests a holistic description of the entrepreneurial phenomenon and is able to provide prescriptive insights. As a matter of fact the process-based approach enables the use of behavioral models of entrepreneurship, such as Entrepreneurial Management (EM) or Entrepreneurial Orientation (EO): as recalled by Lumpkin and Dess (1996; p. 136) the emphasis in entrepreneurship research – following the strategic management discipline – has ‘shifted to entrepreneurial processes, that is, the methods, practices, and decision-making styles managers use to act entrepreneurially’. We believe the process-based approach and behavioral model of entrepreneurship are coherent with our research perspective since ‘firm-level entrepreneurial behavior is affected by and therefore can be managed through the creation of particular organizational strategies, structures, systems, and cultures. As such, a behavioral model of entrepreneurship allows for considerable managerial intervention, and the entrepreneurial process can be viewed as much less serendipitous, mysterious, and unknowable’ (Covin and Slevin, 1991; p. 8).

As Audretsch (1995) argues, entrepreneurship is about change, and entrepreneurs are agents of change; entrepreneurship is thus about the process of change. Others also suggest the same: ‘Entrepreneurs are agents of change and growth in a market economy and they can act to accelerate the generation, dissemination and application of innovative idea’ (OECD, 1998; p. 11); change can be seen as a pervasive dimension, acting at both technical (Tomkovick and Miller, 2000), economical (Stam and Garnsey, 2007) and institutional (Finon and Staropoli, 2001; Sine and David, 2003) levels, and entrepreneurship as a dynamic process always involves change (Fayolle, 2007). Link and Siegel (2007) introduce

the idea of the entrepreneur as a leader of change, by recalling Weber's (disequilibrium given by the changing nature of demand) and Schumpeter's (entrepreneur as a factor contributing to economic change and development through innovation) approaches to entrepreneurship. As a comprehensive example about this relation, we recall here the description provided by Sine and David (2003) on how environmental jolts created entrepreneurial opportunities in the electric power industry in the US, representing an exogenous stimulus to entrepreneurship. A similar contribution comes from Lant and Mezias (1990) and Zahra et al. (1999), by introducing corporate restructuring and renewal through innovation, risk taking and proactive behavior, namely EO.

So far definitional literature on entrepreneurship has concentrated on concepts of change (as well as newness, opportunity recognition and exploitation, growth). Based on the review of literature we made, we believe an insightful contribution can be made by adding that entrepreneurship is also about knowledge. Even the 'change-driven' view of entrepreneurship suggests that sources of opportunities are represented by a discontinuity in available information and knowledge (existing vs. new) (Link and Siegel, 2007), and different levels of entrepreneurial posture can be associated with different ways of reaction in the process of collecting and structuring such knowledge (Fayolle, 2007). Johannisson and Mønsted (1998), using the network metaphor of entrepreneurship, frame the knowledge-based view of entrepreneurship in terms of learning and sense-making. On the role of sense-making in the entrepreneurial process, we should recall that in that view entrepreneurial knowledge is about connecting the dots to see opportunities others do not see. An emphasis on knowledge creation is therefore robustly linked to the change-based view of entrepreneurship and explains the impact of cognitive processes in its understanding.

Knowledge and its accumulation enables the recognition or the generation of opportunities (Marsili, 2002; Fayolle, 2007). This can lead to shaping innovation activities and introduces entrepreneurial development of technology-based companies, as explained in the next section, since technological change (Funk, 2008) is also the result of a continuous interaction process between knowledge evolution and exploitation. Knowledge is also the perspective through which technological change can be understood, as the next section shows.

3. Technological change: dimensions and causes

Technological paradigms have been defined by evolutionary economics (Freeman and Perez, 1988) as the domain for new technological opportunities to emerge and their exploitation to occur. The evolution of technological paradigms triggers opportunities for entrepreneurship to flourish and is governed by the technological trajectories (Dosi, 1982) which describe technological change as a process which is cumulative, incremental and path-dependent by nature. Technological changes can be defined as ‘continuous’ and ‘discontinuous’ (Dosi, 1982); the former occur in the development of extant technological trajectories defined by technological paradigms. The latter are associated with the selection and emergence of new technological paradigms, originating from the interaction of scientific development, economic turmoil, international spillover and unsolved difficulties with existing paradigms (Dosi, 1982), and are always associated with a degree of uncertainty (Tyre and Hauptman, 1992; Negro et al., 2008).

We already mentioned Fayolle (2007), who suggests the interesting perspective of entrepreneurship as process, recalling Gartner (1988); while doing so, the author also indicates technological change as characterized by a dynamic dimension (the main rationale is that technological change, similarly to entrepreneurship, develops through a logic based on progression of events).

It is particularly interesting to observe how industry structure varies and evolves thanks to technological change; industries built around new technological paradigms (Jones et al., 2001) experience strong competition, especially in the development of new standards, focusing on product technologies. Along the establishment of a technological paradigm, the competition is more concentrated with process technologies and cost effectiveness. Voala (2006) provides an evocative example of the impact of technological change on industry dynamics, in the case of the petroleum industry structure, acting as exogenous shock.

From the evidence reported so far, similarly to entrepreneurship, the development in the field of technological change also seems very much interrelated with the knowledge dimension. The emergence of technological change can be associated with the emergence of new knowledge, and the likelihood for the emergence of entrepreneurial opportunities increases with ‘knowledge-base distances’ (Mina, 2009) of firms. In the race for

technological change, it is shown that differences in firms' technological performance are explained, among others, by knowledge exploitation capabilities (Bergek et al., 2008). By the definition of Nelson and Winter (1982), evolutions of technological regimes are a source of entrepreneurship: opportunities for different forms of entrepreneurship are shaped by the nature of knowledge bases underlying different technologies, and links between entrepreneurship and change become indeed more indisputable right in the technology domain.

4. Technological change and entrepreneurship: two sides of knowledge

The interrelation of entrepreneurship and technological change is particularly intriguing since it is bidirectional; this raises much interest in scholars and policy makers as well as entrepreneurs and managers, and constitutes the topical interest of this chapter. We have retrieved an abundant set of evidences in literature about this relationship, which we try to summarize below.

Radical technical discontinuities provide opportunities for the funding of new firms, so that the emergence of new technologies often occurs along with the emergence of a pattern of entrepreneurial activities (see Woolley, 2010 for a detailed description of radical discontinuities in the case of process technologies). The development of technology also goes together with economic and industrial structure trajectories; the emergence of a technological paradigm is often associated with a Schumpeterian shock (Dosi, 1982) and creates conditions of uncertainty and risk (Tyre and Hauptman, 1992) as well as of opportunities for entrepreneurship to flourish. Recent years have shown, following exogenous technological changes, the emergence of enterprises and entrepreneurs (Arend, 1999) as a result of knowledge discontinuities and extraordinary opportunities. Interesting examples on how they can ignite entrepreneurial development through the strategic use of emerging technologies is provided by Skok and Baird (2005).

Van Merkerk and Smits (2008) have highlighted the importance of commercialization activities, as the crossroads of technological change and entrepreneurship. This is particularly true in the case of new firms, which can leverage on smallness and flexibility to commercialize disruptive technologies (Carayannopoulos, 2009).

The pattern through which technological change can induce entrepreneurial development requires organizational responses from both firms (Tao et al., 2010) and industries (Soukup and Cooper, 2009; Ehrnberg and Jacobsson, 1997). Benner (2009) describes the case of technological change in the photography industry and shows that technological change diffuses thanks to firms able to adopt new practices as a response to major technological change and uncertainty.

Khan and Sokoloff (1993) examined patent data and bibliographical information on 160 inventors credited with important technological discoveries, and found that great inventors were also entrepreneurial since they responded systematically to market demand, sometimes redirecting their activities, and pursued investors' return as a priority. Scientific and technological development is so rapid and pervasive that market pulled technological transfer activities are more and more consistently considered as part of science and technology (Van Merkerk and Smits, 2008). On the other hand, we acknowledge a growing interest from both researchers and policy makers into new ventures generated in the academic and scientific environment, as an idiosyncratic and particularly promising form of entrepreneurship which deserves attention and original supporting tools (Link and Siegel, 2007; Wright et al., 2007). Academic research has also acknowledged the reverse causality between technological change and entrepreneurship (Audretsch, 2007, 2009; Stam and Garnsey, 2007). As many authors have shown, countries which have adopted more encouraging policies in favor of entrepreneurship and new firm development reach surprising and considerable levels of technological change and innovation (see, for instance, Woolley and Rottner, 2009 for the case of nanotechnology). Ács and Varga (2005) found a positive and significant impact of entrepreneurial activity in the European Union on the level of technological change.

One of the most interesting documentations of the causality between entrepreneurship and technological change is provided by Peters and Coles (2010), who perceive dimensions such as risk taking and proactiveness (visionary behavior) as crucial to the development and commercialization of a fuel cell technology. Another example is the analysis of breakthrough technologies developed as a response to legislation constraint: Tao et al. (2010) describe how, through a 'proactive R&D management', a smart entrepreneur managed to achieve a breakthrough in the automotive catalytic converter technologies. The

proactiveness of entrepreneurial behavior is indeed directed towards markets and customers, since product design and technological capabilities are not sufficient per se to guarantee successful introduction and diffusion of technologies (Malik, 2001).

5. Innovation dynamics at the crossroads between entrepreneurship and technological change

Much research effort in the field of technological change comes from contributions that are related to strategic management of innovation. While reviewing such contributions we experienced several challenges in clarifying their link with entrepreneurship, which – although claimed – is often implicitly taken for granted. The justification for a contribution being in the domain of entrepreneurship sometimes refers to the mere choice of a small business strategy or a new venture inception as the object of analysis, with lack of theoretical elaboration of entrepreneurship as a construct.

We argue it is possible to move a step ahead in that sense and contribute to the literature on technology entrepreneurship by suggesting an explicit link between innovation dimensions or techniques (in particular we have chosen here to focus on dynamic capabilities, absorptive capacities, network management and ambidexterity, as examples) and the entrepreneurial behavior of firms. This could in a certain sense embrace a perspective of entrepreneurial innovation, showing that entrepreneurial posture can be an antecedent of innovation, but also clarifies and unravels the mutual link between entrepreneurship and technological change we have argued for above. Some examples of this mapping attempt follow, and a conceptual map concludes the Section. In doing this – in coherence with the approach described in Section 1 – we rely on EO as framework to capture and fully describe the entrepreneurial phenomenon.

In the case of technological change, knowledge sourcing and integration capabilities explain the differences in firm performances (Bergek et al., 2008); furthermore the approach to entrepreneurship as ‘a matter of knowledge’ discussed above, allows an original interpretation of concepts like ‘absorptive capacities’ (Lim, 2009) and ‘dynamic capabilities’ as related to the entrepreneurial phenomenon. Dynamic capabilities are defined by Zahra et al. (2006) as ‘the abilities to reconfigure a firm’s resources and routines in the manner

envisioned and deemed appropriate by its principal decision-maker(s)'; as noted by Teece and Pisano (1994) dynamic capabilities 'emphasize the key role of strategic management in appropriately adapting, integrating, and re-configuring internal and external organizational skills, resources, and functional competences toward changing environment', thus allowing for organizational transformation, such as the emergence of technological change (Rosenbloom, 2000; Santangelo, 2005, p. 13): 'The introduction of technological change is the outcome of a process of creative adoption where external knowledge and new technologies made available in the market are recombined with the knowledge generated internally by means of learning processes and research and development (R&D) activities'. Dynamic capabilities are found to stimulate innovation through NPD processes (Deeds, 2000) and to represent a theoretical evolution of the resource-based view of firm, in the sense that they enable the exploitation of resources (Newbert et al., 2008) and organizational renewal through cognitive changes (Barr et al., 2007). They translate opportunities (defined as 'market circumstances' by Helfat, 1997) and exogenous technical changes in a sustained competitive advantage. Though much research has to be devoted to the possible reconciliation of strategic management and entrepreneurship, an interesting overlapping between the two domains can be found right in the link between dynamic capabilities and corporate entrepreneurship (Teece et al., 1998; Phan et al., 2009). Established firms, in order to compete, have to foster entrepreneurial behavior as a pervasive character of their style; in the case of gas turbine industry described by Bergek et al. (2008), capabilities are found to play a crucial role in fostering industrial dynamics and renewing mature industries through technological discontinuities. Zahra et al. (2006) stress the importance of advancing research on dynamic capabilities and SMEs and new ventures, suggesting the relevance of dynamic capabilities for the concept of entrepreneurship in general. There are several dimensions of entrepreneurship as firm behavior that can foster the dynamic capabilities of firms, acting as antecedents of it, in particular dynamic resource allocation may be enhanced by risk proclivity – one of EO's dimensions – and focus on analysis within a strategic posture (Venkatraman, 1989).

Absorbing external knowledge from spillover is crucial to technical change and requires strategic investments in activities that increase firms ability (Cohen and Levinthal, 1990). Despite their theoretical importance, the concept of absorptive capacities still suffers

inconsistent definitions (Lim, 2009) and little attention is claimed by Lane et al. (2002) to have been paid by scholars to the actual processes underlying absorptive capacity. Starting from Nicholls-Nixon and Woo (2003) absorptive capacity is seen as the ability to identify and assimilate external new knowledge and to exploit it for commercial purposes through innovation. It involves R&D management and organization, which in turn can be fostered by technological proactivity (García-Morales et al., 2007) and alliance proactivity (Benson and Ziedonis, 2009). May we here recall Ferreira and Azevedo's (2007) indication of EO as an antecedent of absorptive capacities in determining small firms' growth, especially through emphasis on R&D (see also Covin and Slevin, 1989) and proactive use of networks. Entrepreneurial networks are 'a framework for processes aiming at organizing resources according to opportunities' (Johannisson and Mønsted, 1998; p. 112) and help us in moving a step ahead from absorptive capacities. According to Johannisson et al. (1994), the strategic use of a contextual network suggests that the potential of entrepreneurship can be explained and captured by an organizing function called 'contextual network' which ensures the coordination of functional areas (also outside the firm, see Venkatraman, 1989) and is fostered by autonomy – one of EO's sub-dimensions – as entrepreneurial firm behavior (Lumpkin et al., 2009).

Another issue that constantly emerges from our review is the need for simultaneous and balanced adoption of exploration and exploitation practices within a single company. Coming from organizational science, this posture is defined as ambidextrous and is structured through organizational mechanisms that translate entrepreneurial posture into competitive advantage and firm performance (Kollmann and Stöckmann, 2008; see also the framework and the whole literature review in Raisch and Birkinshaw, 2008). Exploitation can be seen as a consequence of customer orientation, whereas exploration is stimulated by proactiveness (EO) and entrepreneurship as an act of stimulating newness. Jansen et al. (2005) claim the former is fostered while the latter is hampered by centralization and formalization. Most important, Kyriakopoulos and Moorman (2004) argue that the complementarity and right balance of the two is enabled by a firm's market orientation, which in turn is a consequence of proactiveness and competitive aggressiveness. The link to EO is therefore evident, and due to its nature of strategic organizational behavior, it can be

further assimilated to seeking new opportunities and market development (Venkatraman, 1989), changes in products/services, proactiveness and an aggressive posture in an uncertain market (Covin and Slevin, 1989).

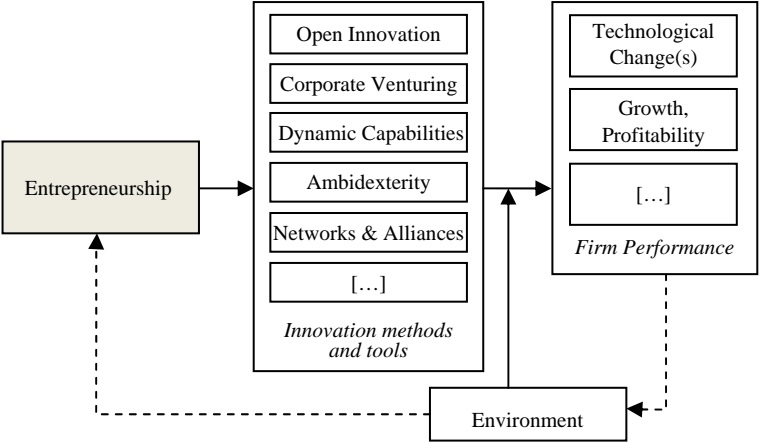


Figure 1.1: Conceptual map of the relation between entrepreneurship, innovation and technical change

We conclude the section with Figure 1.1, that represents a map of the literature we have considered in our analysis on the relationship between entrepreneurship and technological change, mediated by two dimensions: environment, which can be the space where jolts take place and are ignited, and strategic innovation, which represents the amount of tactics, tools and strategies (we have previously analyzed three of these and set them in a direct link with the entrepreneurial posture of firms) that enable technical change. From a firm level perspective, technical change is one of organizational performance, together with growth, profitability and others; the forward causality (continuous lined arrows) represented in the map is conceptually very similar to a large set of contingent models on the entrepreneurial determinant of firm performance (see Moreno and Casillas, 2008). In turn the ‘feedback loop’ (dotted lined arrows), the impact of technical change has on entrepreneurial posture of the firm, is somewhat coherent with Covin and Slevin (1991) seminal work on EO.

Entrepreneurship is found to foster Schumpeterian innovation: production of a new good, new production methods, new market exploration, new procurement sources and alliances, and re-organization of firm or industrial activities. The contributions that most clearly present entrepreneurship as the antecedent of innovation are Montalvo (2006) and Rhee et al. (2010). The contribution of the present work is the shedding of new light and the attempt to

systematize the explicit link between EO and innovation dynamics, which in literature is often implicit and taken for granted.

6. Discussion and conclusion

The relationship between entrepreneurship and technological change is multifaceted, involves different levels of analysis, and one may argue that a bridge between them is the concept of knowledge. Accumulation, development and integration of knowledge determine shifts in the technological paradigms and trajectories, originating technological change. Such accumulation of knowledge is a dynamic process, often shaped by market and business pulls, and is fostered by entrepreneurial posture. Entrepreneurship, too, is about knowledge since sources of opportunities are changes and discontinuities associated with entrepreneurial types of reactions (Link and Siegel, 2007). So if traditionally change and growth are considered the structural dimensions and expression of entrepreneurship, we also consider knowledge creation and integration as constitutive of the entrepreneurial phenomenon.

This chapter, through the revision of a large amount of theoretical and empirical papers in the field, has shed new light on technological entrepreneurship linking it to (strategic) innovation forms. We have suggested entrepreneurship as the antecedent of innovation in the generation of firm performance.

The role of entrepreneurship in fostering innovation stimulates a consideration from the perspective of the neo-evolutionist approach in economics. The Schumpeterian contribution suggested that firm dimension and innovative firm concentration in the market are the main drivers of the patterns of innovation activities. The concept of entrepreneurship, mainly expressed as new economic activity or small business ownership, was not caught in its integrity, i.e. as organizational posture and behavior. Several decades on, after a substantive theorization on EO, on entrepreneurial processes and their determinants, and on the nature of entrepreneurship, we acknowledge a substantial shift in the understanding of the relevant determinants of innovation patterns: it seems that entrepreneurship as firm behavior has gained a much more relevance, as market oriented behaviour (Leiponen and Drejer, 2007),

and this can be recognized in new ventures, established SMEs or large corporations to the same extent.

Research in this field has been pursued continuously and with growing interest due to new and rapidly emerging technological paradigms. We believe an interesting exercise could be done by mapping other innovation tools and approaches (such as open innovation, corporate venturing, M&A strategies) under the lens of entrepreneurship and in particular EO. From the empirical point of view we also believe there is room for considerable contribution in the field; the conceptual map highlights a ‘positive feedback’ mechanism, which can occur continuously, generating – through a virtuous iterative cycle – sustained technical progress and a diffusion of entrepreneurial phenomena. A very promising research exercise could be done by trying to describe such virtuous dynamics, and finding empirical evidence on its enabling factors.

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