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Sleeping Beauties and their princes in innovation studies

Aurora A. C. Teixeira[1,2,3] · **Pedro Cosme Vieira**[4] · **Ana Patrícia Abreu**[4]

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Abstract A Sleeping Beauty (SB) is a publication that goes unnoticed for a long time, and then, almost suddenly, is awakened by a 'prince' (PR), attracting from there on a lot of attention in terms of citations. Although there are some studies on the SB and the PR phenomena in the sciences, barely any research on this topic has been conducted in the social sciences, let alone in innovation studies. Based on 52,373 articles extracted from the Web of Science and using a new method that, comparatively with extant methods, selects SBs with the highest scientific impact, we found that, similarly to the sciences, SBs are rare in the field of innovation (<0.02%). In contrast with the sciences, the depth of sleep is relatively small, ranging from 7 to 17 years. All the 8 SBs found, and the (37) corresponding princes, were published in highly renowned journals (e.g., *Harvard Business Review, Journal of Management Studies, Organization Studies, Rand Journal of Economics, Research Policy*). The explanations for the delayed recognition are associated with innovative methods, scientific resistance, and theoretical-relatedness. The role of highly influential authors and self-awakening mechanisms were critical triggers for bringing SBs into scientific notoriety.

Keywords Sleeping Beauty · Prince · Delayed recognition · Awakening intermittency · Innovation

✉ Aurora A. C. Teixeira
ateixeira@fep.up.pt

[1] CEF.UP, Faculdade de Economia do Porto, Universidade do Porto, Rua Dr Roberto Frias, 4200-464 Porto, Portugal

[2] INESC TEC, Porto, Portugal

[3] OBEGEF, Porto, Portugal

[4] Faculdade de Economia, Universidade do Porto, Porto, Portugal

Introduction

Scientific works are the engine of knowledge development which has led significant public and private resources to be allocated to research and development activities (Holsapple and O'Leary 2009; Cattaneo et al. 2016; Kumar et al. 2016). However, the efficient allocation of resources requires the output of those individuals who are involved in producing science to be evaluated (Hawkins et al. 1973; Drew et al. 2016; Marzolla 2016). Such evaluation, especially in the basic sciences, is very difficult because there is a substantial time lag between the publication of the 'discovery' and the visibility of its impact on society (Glänzel et al. 2003). To overcome this limitation, an increasing number of institutions use journal citations as a measure for the value of the 'discovery'. In addition, a reasonable number of studies (e.g., Kalaitzidakis et al. 2001; Ma et al. 2013) have been developed in order to assess the 'quality' of publications or their authors based on the number of citations that the publications receive (for a review, see Waltman 2016).

The evaluation of the possible relationship between the future impact on society of the 'discovery' described in the article and the number of citations the publication receives has focused the attention of scholars in the areas of scientometrics and bibliometrics (Glänzel et al. 2003), who seek to find appropriate forms of assessment, including assessment by peers and number of citations and co-citations (to discover the networks linking authors).

Observing the time path of the number of citations, it has been noted in the literature that there are articles that initially were "dormant" for several years (Lange 2005; Cressey 2015; van Raan 2015). This phenomenon attracted much attention, especially in science, resulting in the emergence of a new concept, 'Sleeping Beauties' (van Raan 2004). These are articles which are not cited or rarely cited for a long period of time, but suddenly begin to attract a lot of attention (i.e., they start being cited with significant intensity). The reasons for the change in the pattern of citations may include a paradigm shift in the study area (van Raan 2004; Wang et al. 2012) or, for example, the papers have been written by a researcher who suddenly achieves notoriety, e.g., by winning the Nobel Prize (e.g., the prizes in physics awarded to Chadwick in 1935, Davisson and Germer in 1937, and Kapitza in 1978—see Li and Ye 2012). However, the explanations for the SB phenomenon are as yet still underexplored (Ke et al. 2015).

In the bibliometrics literature, SBs are often associated with concepts such as 'delayed recognition' (Cole 1970), 'resisted or premature discoveries' (Barber 1961; Wyatt 1961), and 'information awakening' (Wang et al. 2012). The term SB was first used by van Raan (2004), but this phenomenon, using a distinct terminology, had already been discussed previously by Garfield (1980) and Glänzel et al. (2003). SBs have been mostly analyzed in the sciences-related literature (van Raan 2004). Although relatively rare (<0.1% of the total published papers), they are considered a very common phenomenon in the sciences (Wang et al. 2012; Lachance and Larivière 2014).

The empirical evidence shows that SBs are usually of great value to science (Hu and Wu 2014), being "a rather useful and instructive model in studying the mechanisms of scientific information flow" (Braun et al. 2010: 195). Some studies have shown that SBs, namely those associated to Nobel Prize Laureates (Li and Ye 2012; Li 2014; Li et al. 2014a, b) were initially ignored by fellow scientists. It is argued that those papers, had they been accepted earlier by peers, would have contributed to a faster development of science and technology (Wang et al. 2012). Thus, this empirical evidence indicates that the study of SBs is necessary to better understand the reasons for their late recognition and why the 'information sleeps' (Wang et al. 2012). Moreover, as Ke et al. (2015: 1) underline, "the

study of SBs provides empirical evidence against the use of short-term citation metrics in the quantification of scientific impact".

Although common in the sciences, in the field of innovation SBs, let alone their princes (PRs), have never been studied or assessed. This study is also relevant because innovation is considered one of the most important issues in today's business research (Hauser et al. 2006), as "the primary driving force of progress and prosperity" (Volberda et al. 2013: 2). Moreover, as a broad topic, diverse disciplines, namely marketing, quality management, operations management, technology management, organizational behavior, product development, strategic management, and economics, focus on various aspects of innovation (Hauser et al. 2006), which supports the idea that the study of SBs in this field can contribute, even if only indirectly, to the understanding of the evolution of related areas.

In this context, this study aims to assess the magnitude of the SB phenomenon in innovation studies, to explain the reasons for their delayed recognition, and uncovering the main awakening mechanisms. By studying the citation profile of potential SBs, we intend further to contribute to a better understanding of the flow of scientific production and practices in this stimulating area of research. To the best of our knowledge, despite the existence of a reasonable number of high-quality bibliometric studies in the field of innovation (e.g., Butcher and Jeffrey 2005; Uriona-Maldonado et al. 2012; Fagerberg et al. 2012; Di Stefano et al. 2012; Leydesdorff et al. 2013; Liu et al. 2015), none has tackled the issue of SBs or their PRs.

Based on a quantitative/bibliometric methodology, we propose a new method adapted from van Raan's (2004) approach capable of identifying candidates SBs with high scientific impact from among thousands of papers. Such an approach is applied to a population of 52,373 papers published between 1951 and 2014, extracted from the Web of Science bibliographic database with 'innovation' as the keyword (filtered by 'social science' and 'business economics'). From a much smaller set of (5296) papers, published between 1951 and 2005, which were cited 20 or more times, we found the 'potential'/candidates SBs. After the identification of the SBs, they were further scrutinized in order to find the 'princes' (PRs), as well as the reasons behind their late recognition and/or awakening.

In terms of structure, the paper is organized as follows. The next section presents the literature review, followed ("Methodological considerations" section) by a discussion of the methodology. "Empirical results" section details the results and "Conclusion" section concludes the study.

A review of the literature on Sleeping Beauties (SBs) and their princes (PRs)

The number of studies on SBs has substantially grown in the last 3 years. Indeed, out of the 56 studies on SBs identified in Scopus Sci Verse,[1] 30 (56%) were published in 2014–2016. However, only a meagre fraction (11% of the total/6 papers) addressed the identification of the PRs of the SBs (Braun et al. 2010; Wang et al. 2012; Li et al. 2014a, b; Huang et al. 2015; Du and Wu 2016; Li and Shi 2016).[2] The PR is the document that awakes the dormant study/SB, that is, brings the SB to wide scientific attention (Huang et al. 2015).

[1] Reference date: June 2016.

[2] The article by Li and Ye (2012) mentions SBs' princes but it does not explicitly identify them.

The occurrence of SBs has been addressed previously in the literature and the assumption that they contain an idea ahead of their time set by a young scientist of lower academic status has been gaining strength (Liang et al. 2009; in Ma et al. 2013). Other reasons have been pointed out, based on the study of SBs in distinct fields of research, such as Ophthalmology (Ohba and Nakao 2012) or Physics/Medicine/Human evolution (Li and Ye 2012). In the first field, Ohba and Nakao (2012) conclude that the time needed to confirm and expand experience with new diseases and technologies is likely to be relevant in explaining the delay in the citation recognition of clinical studies.

Given that SBs exist, the process we intend to understand is how are they awakened and, in this analysis, as important as finding the SBs, there is the need to understand and find out how SBs were awakened or which related paper/issue awakened them (see Braun et al. 2010). For instance, referring to Francis Peyton Rous's 1911 paper ('A sarcoma of the fowl transmissible by an agent from the tumor cells'. *Journal of Experimental Medicine*, 13: 397–411), Li and Ye (2012: 799) uncovered that "[o]nly after a leukemia virus was isolated in 1951 could Rous' discovery be appreciated … [setting the start of] the virus-theory trend in cancer research."[3]

Aiming to understand the phenomenon of SBs, Wang et al. (2012) conduct a qualitative study where they establish that some basic elements of information use are important for information awakening: information value, access channel and user needs/user demand. They contend that the sooner we understand the reasons behind a SB, the faster we can establish a better mechanism to awaken them and maximize their value.

Also concerning the awakening of SBs, Li et al. (2014a, b) address the 'heartbeat spectra' for SBs and conclude that publications which possess 'late heartbeats' (most citations were received in the second half of the sleeping period), have a higher probability of awakening than those that have 'early heartbeats' (most citations were received in the first half of the sleeping period).

A PR is indispensable for this awakening process, because it is the fundamental piece that leads the SB to attract much more attention (van Raan 2004; Du and Wu 2016). However, finding a PR is a common difficulty among studies and it is not always easy to decide which paper(s) might be considered the PRs (Kozak 2013; Li et al. 2014c). Kozak (2013) suggests that it is possible that any type of paper constitutes the 'prince', such as a conference paper in which the SB is discovered. This author's position differs from van Raan's (2004), who says that the PR is the first paper citing the SB. In identifying the PR, Ohba and Nakao (2012) found that self-citations can play the role of PR in the SBs. Thus, there is a chance that the author of a SB is also the author of the SB's PR (a co-citation). More recently, in the line of Braun et al. (2010), Du and Wu (2016: 1) propose that candidate PRs should meet several criteria, most notably: "be published near the time when the SB began to attract a lot of citations; be highly cited papers themselves; [and] receive a substantial number of co-citations with the SB".

In the challenging task of finding SBs, various studies have been based on equal or similar methods. Several authors (e.g., van Raan 2004; Burrell 2005; Ohba and Nakao 2012; Li 2014; Li et al. 2014a, b; Ke et al. 2015) based their methods on three main variables—(1) the 'depth of sleep', (2) the 'length of sleep', and (3) the awake intensity (*cw*)—and proceeded to a quantitative analysis of delayed recognition.

According to van Raan (2004), the depth of sleep can be defined as an article that receives at most one citation on average per year (*deep sleep*), or between one and two citations on average per year (*less deep sleep*), over a minimum period of 5 years (*length of*

[3] Peyton Rous was awarded the 1966 Nobel Prize in medicine for his work on cancer virus.

sleep) and, after this period, receives a substantial number of citations (*awake intensity*). Using those same three variables, Ohba and Nakao (2012) take into account a different awake intensity, considering the total citations per year during the 5 years following the sleeping period, instead of the 4 considered by van Raan (2004). These authors argue that for a paper to be classified as a SB it has to be cited at least 100 times after its date of publication. Assuming an awake intensity (*cw*) of 100 citations over a minimum period of 5 years, Ohba and Nakao (2012) screened citation histories of 184,606 articles in 52 ophthalmology journals using the Science Citation Index-Expanded (Thomson Reuters) and identified nine articles as SBs. Considering the same three variables, Li (2014) studied all the stages of a SB, defining the process as 'all-elements-sleeping-beauties', which contains a sleeping period, an awakening period and a happy ending (where both the princess and the prince grow old together ever after the awakening period, since both citation curves synchronously decayed). In order to understand the duration of the sleeping period, Li et al. (2014a, b) examined 58,963 papers by Nobel Laureates and applied a Gs index in order to measure the inequality of the 'heartbeat spectrum', which indicates the duration of the sleeping period. A 'heartbeat' refers to the number of citation(s) the SB receives each year in the sleeping period (Li et al. 2014a, b). Following a similar procedure to Li et al. (2014a, b), Ke et al. (2015) computed a parameter-free 'beauty coefficient' that enables to measure how much a certain paper is a SB. According to the authors, their approach overcomes some limitations of earlier approaches for identifying SBs, including that of van Raan's, as it is not "affected by an arbitrary selection choice of top SBs" (Ke et al. 2015: 2).

The method applied by van Raan (2004) is substantiated in the computation of the so-called 'Grand Sleeping Beauty Equation'. This equation provides the number of SBs for any sleeping period, sleep intensity and awakening intensity. His observations led him to conclude that "the probability of awakening after a deep sleep is smaller for longer sleeping period" and "for a less deep sleep, the length of the sleeping period matters less for the probability of awakening." (van Raan 2004: 462).

The study of SBs is required in any field to ensure that the academic information remains useful to society (Wang et al. 2012). This involves the identification of SBs in various areas of knowledge and seeking ways to awaken information with potential value to society that is in a 'sleeping' state. The fact that a given paper receives very few citations after publication and over a relatively long time span but whose citation suddenly spurts should be the object of an in-depth study/analysis rather than be ignored. SBs have been proven to be important in science as they can involve new knowledge in the form of new or changed paradigms and/or new theories whose content is too advanced to be widely grasped (Garfield 1980; Lange 2005; Ma et al. 2013). If they had been found and accepted earlier, both science and technology may have developed faster (Wang et al. 2012). Thus, it is highly pertinent to identify and analyze SBs in other fields of knowledge, as their excessive presence may cause idleness and a waste of knowledge (Wang et al. 2012).

Bearing in mind that research on innovation has been conducted in a number of disparate fields in a variety of disciplines, the discovery of SBs in innovation related research can contribute to an understanding of the evolution of fields related to innovation, like marketing, quality management, operations management, technology management, organizational behavior, product development, strategic management, and economics (Hauser et al. 2006). It can also give us a notion that regardless of the current or short-term citation patterns of a given article, articles that are ahead of their time may exist and, as such, researchers, editors and policy-makers should not ignore or underestimate the importance of currently low-cited papers.

Methodological considerations

In order to conduct a quantitative analysis of SBs in the field of innovation, we based our analysis on the bibliometric approaches of van Raan (2004), Burrell (2005), Ohba and Nakao (2012), Li (2014), and Ke et al. (2015). This involved computing indicators that aggregate the 'depth of sleep', the 'length of sleep', and the 'awake intensity'. As a preliminary step, we computed an indicator similar to standard deviation to identify from among thousands of papers downloaded from the Web of Knowledge database the few that had the potential to be Sleeping Beauties. This step is crucial in the analysis and it is new to the literature.

Procedure to find the Sleeping Beauties (SBs)

The implementation of the approach we have employed to identify the SBs started with the gathering of articles published and indexed in the Web of Science, using 'innovation' as the search keyword, filtered by 'social science' and 'business economics', over an extensive time period from 1951 to 2014.[4] The number of papers extracted amounted to 52,373. Then, first, we excluded from the data set all the papers with <20 total citations from the date of their publication until October 2014 and also those published after 2005. This reduced our database from 52,373 papers to 5296 papers. It should be noted that, in comparison to the study of Ohba and Nakao (2012), which only included those papers with 100 or more total citations, our analysis is more comprehensive, since it can identify cases where the awakening intensity is more intense, thus making the analysis of the reasons for the occurrence of SBs more challenging.

Second, we ranked all the papers using an indicator similar to a standard deviation by applying the following formula (with a time span of 20 years):

$$K = \left(\frac{\sum_{i=\text{yop}}^{\text{yop}+20} (i - \text{yop})^2 \text{noc}_i}{\sum_{i=\text{yop}}^{\text{yop}+20} \text{noc}_i} \right)^{0.5} /20,$$

where yop is the year of publication and noc_i is the number of citations in the year i.

We have computed this indicator ourselves, which is new to the literature. The K value has an empirical distribution (see, Fig. 1), which allowed us to identify the SBs among the 5296 papers selected in the first phase. On this basis, the candidate SBs would have a high K value, whereas the 'flashes in the pan' would have a low K value. Assuming that SBs are exceptional events in (social) science (see Baumgartner 2010; Lachance and Larivière 2014), we considered that the K value for candidate SBs should fall in the top 1% of the papers (interval between 0.785 and 1.0).

Comparing our procedure for finding potential SBs with the pioneering method by van Raan (2004) or the recent measure of Ke et al. (2015), the results obtained are distinct. The top 1% (53) papers identified by the three above mentioned metrics shows that between our list and that of van Raan's, and between Ke et al.'s and van Raan's lists, there is no paper in common. Between our list and that of Ke et al. there are 13 (25%) papers in common. Although Ke et al.'s procedure has the advantage of not relying on arbitrary thresholds on the sleeping period or the awakening intensity, our metrics has the advantage of identifying the papers that in the future present a higher scientific impact (i.e., receive more citations)—see Fig. 1. Indeed, the top 1% papers identified by our metrics received in the first

[4] The reference date for extracting the data was October 13th, 2014.

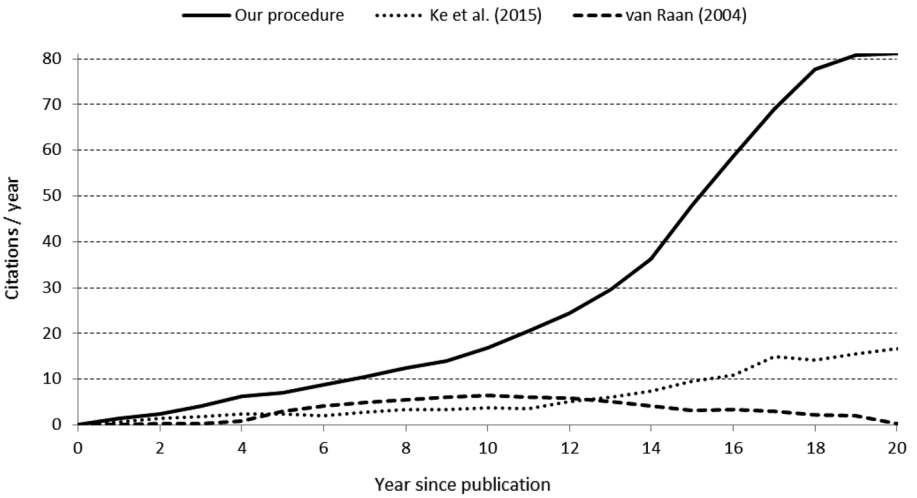


Fig. 1 Comparing van Raan's (2004), Ke et al.'s (2015) and our metrics to find the SBs (average number of citations per year in SBs candidates). *Source*: Authors

20 years after publication a total of 610 citations per paper whereas using Ke et al.'s and van Raan's metrics, the corresponding total is 112 and 67 citations per paper, respectively.[5]

Because the awaken of a SB cannot be the result of a mere statistical fluctuation (Du and Wu 2016), for an article identified in the top 1% to be classified as a SB we have to uncover the article/event that led to its awaken. Thus, in the third phase, and only for the identified SB (i.e., papers with a K value higher than 0.785—see Fig. 2), we scanned the reference list of articles citing the SBs and searched for articles that might act as the 'prince' (PR) in the process of awakening the SB.

Steps for identifying the prince (PR) using co-citation patterns

Once the paper with delayed recognition (i.e., the SB) had been identified, the next stage consisted in examining which article triggered the awakening of the SB (i.e., the PR).

In line with Du and Wu (2016), Ohba and Nakao (2012), and Braun et al. (2010), the procedure that we took to uncover the candidate PRs requires that several conditions are met, most notably that the PR is published nearby the awakening of the SB, it is a well cited paper, and receives a substantial number of co-citations with the SB. Thus, taking the SB's citation time trend, the connection between the SB and the PR is analyzed on the basis of their (co)citation pattern. The PR cites the SB and, subsequently, there are SB-PR co-citations (citations involving articles that simultaneously cite the SB and the PR). Accordingly, to identify the PRs, we complement the time pattern of the SB's citations with the list of articles that cited the SB and each potential PR. In this task, we only selected articles (candidates to be the prince) with more than 10 co-citations, meaning that the PR has to be a reasonably important article in terms of scientific impact in the SB research area (see Huang et al. 2015).

[5] Figure 1 shows that for those papers identified as potential SB according to the van Raan model, on average, the number of citations does not increase over time. Such property is maintained even when the sleeping period is increased from the standard 5 years period.

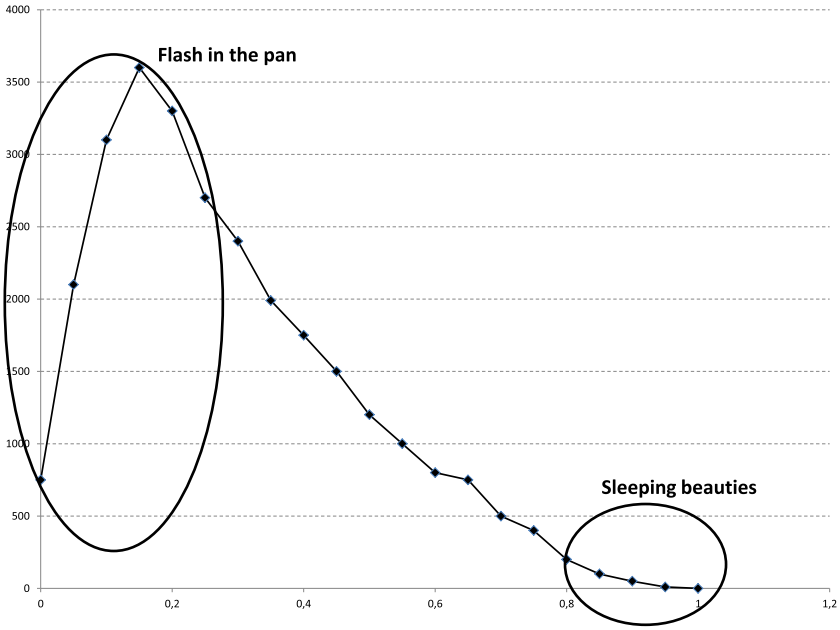


Fig. 2 Distribution of the K indicator used to identify the SB candidates. *Source*: Authors

Summing up, the procedure involves 4 main steps[6]: (1) to extract the list of articles that cited the SB and analyze which of these articles are 'potential' princes; (2) to extract the articles citing each of the potentials PRs and analyze the co-citations (SB and Prince); (3) leave out all those articles with 10 and less co-citations; and (4) reduce the subsequent analysis to the PRs with a large number of citations and co-citations with the SB, taking into account the sleep/awaking moments of the SB.

Empirical results

The SBs in the field of innovation

Using the procedure described in "Procedure to find the Sleeping Beauties (SBs)" section, we ranked the 5296 papers selected using the K indicator ($\left(\frac{\sum_{i=\text{yop}}^{\text{yop}+20}(i-\text{yop})^2\text{noc}_i}{\sum_{i=\text{yop}}^{\text{yop}+20}\text{noc}_i}\right)^{0.5}/20$). As mentioned previously, the K has been constructed so that the SBs have a high K value, that is, $K \in [0.785; 1.0]$.

From the papers selected we were able to identify 8 SBs (listed in Table 1). The number of total citations received by each SB (up to October 2014) ranged from 90 (Gadrey et al. 1995) to 1585 (Kaplan and Norton 1992a, b). The SBs identified were published between 1986 (Barras 1986) and 1995 (Gadrey et al. 1995).

[6] We replicated every step of the process for all the SBs. In the Appendix we detail the procedure for finding the PRs using Kaplan and Norton (1992), the SB with the highest citation count, as an example.

Table 1 Sleeping Beauties identified (ordered by decreasing number of citations). *Source*: Authors

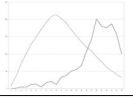
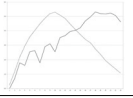
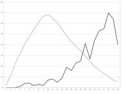
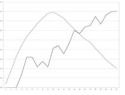
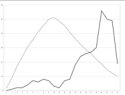
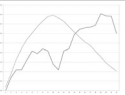
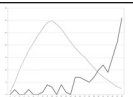
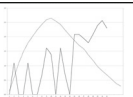
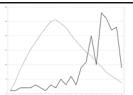
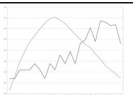
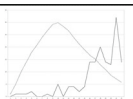
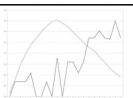
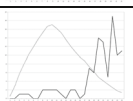
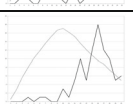
	Title of the article	Author(s) (Year of publication)	Journal [a]	Awakening year (length of the sleep)[b]	Deviation (K)	Total citations in October 2014 (in June 2016)	Graph[c]	In logarithm scale
SB1	The balanced scorecard – measures that drive performance	Kaplan, RS; Norton, D.P. (1992)	*Harvard Business Review* IF2015: 2.249, Rank Business: 33/120 (Q2); Rank Management: 46/192 (Q1).	1999 (7 years)	0.835	1585 (1987)		
SB2	A penny for your quotes – patent citations and the value of innovation	Trajtenberg, M. (1990)	*Rand Journal of Economics* IF2015: 1.582, Rank Economics: 79/344 (Q1).	1999 (9 years)	0.827	522 (619)		
SB3	From value chain to value constellation – designing interactive strategy	Normann, R; Ramírez, R. (1993)	*Harvard Business Review* IF2015: 2.249, Rank Business: 33/120 (Q2); Rank Management: 46/192 (Q1).	2004 (11 years)	0.811	356 (422)		
SB4	Towards a theory of innovation in services	Barras, R. (1986)	*Research Policy* IF2015: 3.470, Rank Management: 20/192 (Q1); Rank Planning and Development: 2/55 (Q1).	1997-2000 (11-14 years)	0.790	233 (282)		
SB5	Organizational size and innovation	Damanpour, F. (1992)	*Organization Studies* IF2015: 2.798, Rank Management: 31/192 (Q1).	2006 (14 years)	0.822	194 (239)		
SB6	Predators and prey – a new ecology of competition	Moore, J.F. (1993)	*Harvard Business Review* IF2015: 2.249, Rank Business: 33/120 (Q2); Rank Management: 46/192 (Q1).	2009 (16 years)	0.830	146 (233)		
SB7	The relationship between types of innovation and organizational performance	Damanpour, F; Szabat, K.A.; Evan, W.M. (1989)	*Journal of Management Studies* IF2015: 4.260, Rank Business: 6/120 (Q1); Rank Management: 12/192 (Q1).	2006 (17 years)	0.829	106 (142)		
SB8	New modes of innovation - how services benefit industry	Gadrey, J; Gallouj, F and Weinstein, O (1995)	*International Journal of Service Industry Management* [currently published as *Journal of Service Management*] IF2015: 2.233, Rank Management: 49/192 (Q2)	2004 (9 years)	0.785	90 (106)		

Table 1 continued

[a] The impact factor considered was taken from the 2015 Journal Citation Report

[b] Authors' estimation

[c] The dotted line represents the average citation pattern of a regular paper (obtained through the average citation pattern of the 5269 papers selected. The reference date for citation data extraction is October 13th, 2014

Research quality is often based on a journal's impact, which is of major importance because it explains both the journal's reputation and its relevance to society (Hawkins et al. 1973; Waltman 2016). The SBs were published in highly renowned journals in the fields of business/management (*Harvard Business Review; Journal of Management Studies; Organization Studies; Research Policy*) and economics (*Rand Journal of Economics*). To relativize the importance of the journals, we ranked them by impact factor (*cf.*, Web of Science/WoS). In the Management category, the SBs identified were published in journals that rank 12nd (*Journal of Management Studies*), 20th (*Research Policy*), 31st (*Organization Studies*), 46th (*Harvard Business Review*), and 49th (*Journal of Service Management*) in a total of 192 journals. In the Economics category, the journal in which the SB was published is ranked 79th (*Rand Journal of Economics*) out of a total of 344 journals.[7]

The selected SBs address four main topics: (1) new methods/indicators/tools to evaluate companies' performance (SB1: Kaplan and Norton 1992a, b) and the economic value of innovation (SB2: Trajtenberg 1990); (2) the importance of interactive/open/ecosystem business strategies (SB3: Normann and Ramírez 1993; SB6: Moore 1993); (3) innovation in services (SB4: Barras 1986; SB8: Gadrey et al. 1995); and (4) types of innovation and organization performance (SB5: Damanpour 1992; SB7: Damanpour et al. 1989).

Robert Kaplan (Harvard University) and David Norton (co-founder and former CEO of Palladium Group) proposed in the 1992 *Harvard Business Review* paper (SB1: Kaplan and Norton 1992a, b) the balanced scorecard as a means to evaluate corporate performance which encompassed, beside the financial perspective, the internal business process, the customer, and the learning and growth perspectives. Offering also a new metrics/tool, this time for the economic evaluation of innovations, Manuel Trajtenberg (Tel-Aviv University) demonstrated, in his paper published in *Rand Journal of Economics,* the usefulness of patent citations as an indicator of the value of innovations (SB2: Trajtenberg 1990).[8] Although taking a while to be widely noted and used—they slept for 7 (SB1: Kaplan and Norton 1992a, b) and 9 years (SB2: Trajtenberg 1990), both works had later profound impacts on business and economics literature as their citations counts demonstrate.

SB3 (Normann and Ramírez 1993) and SB6 (Moore 1993) are the precursors of the business ecosystem innovation movement. Richard Normann (Swedish management consultant 1943–2003) and Rafael Ramírez (Oxford University) co-authored the first major journal articles challenging the 'value chain' view of value production (SB3: Normann and Ramírez 1993). This pioneering research provided an early conceptualization of value creation as designed in what has become since the 'social economy/business ecology/web interaction era. Also challenging the scientific *status quo*, James F. Moore (US management consultant) studied the co-evolution in social and economic systems and pioneer of the concept 'Business ecosystem' (SB6: Moore 1993), a form of organization distinct from and parallel to markets and firms, and its entrance into the lexicon of business strategy. Albeit gaining several prizes, Moore's article took quite long time to achieve wide scientific notoriety (it intermittently slept for 16 years).[9] The business ecosystem concept and unit of

[7] We use here the last available information from Journal Citation Report, Web of Science 2015.

[8] Work developed from his Ph.D. thesis ("Economic Analysis of Product Innovation: The Case of CT Scanners"), received in 1984 from Harvard University.

[9] Moore's SB ("Predators and prey: A new ecology of competition") won the McKinsey Award for best article of the year for 1993. His follow up (1996) book "The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems" was a best-seller and won several awards ("one of the ten best books of the year", BusinessWeek, and "one of the ten best books of the decade for entrepreneurs", Wall Street Journal).

analysis has been found necessary and helpful in business strategy and practice for many years.

SB4: Barras (1986) and SB8: Gadrey et al. (1995) helped to lay the foundations of the still growing body of service-specific innovation studies (Drejer 2004; Witell et al. 2016). They focus on innovation in Services, a topic which has been rather neglected for almost two decades and reached the maturity in the beginning of the twentieth century (Djellal et al. 2013). Richard Barras (Founder/Consultant Property Market Analysis, UK), an urban economist, has made a noteworthy contribution to the development of a theory of innovation applicable to the post-industrial economy, connecting the services shift to a move towards communication technologies. By directing the attention towards features that are perceived as distinctive for service innovation and that are not applied to manufacturing (at least not to the same extent), the French affiliated researchers Jean Gadrey (University Lille I), Faïz Gallouj (University Lille I) and Olivier Weinstein (Université de Paris 13) adopted a demarcation approach to defining and studying innovation in services.

The last group of SBs, which address the types of innovation and organizational performance—SB5: Damanpour 1992; SB7: Damanpour et al. 1989—share one author, Fariborz Damanpour (Rutgers Business School, US) and were awake in the same year, 2006. Damanpour and his co-authors, Kathryn A. Szabat (La Salle University, US) and William M. Evan (University of Pennsylvania, 1922–2009), address a rather underdeveloped topic until mid-2000s, the impact innovation on organizational performance in public agencies/sector (Mafini 2015). As Djellal et al. (2013: 98) recognized, "[s]ervice innovation was neglected for a long time, but … [i]nnovation in the public sector has been even more neglected in the mainstream of innovation studies." The meta-analysis study by Damanpour (1992) (SB5) demonstrates that innovation is positively related with the size of an organization and that such relation is mediated by the type of organization, most notably manufacturing versus services, and profit versus non-profit.

SB4 (Barras 1986)/SB8 (Gadrey et al. 1995), and to a lesser extent SB5 (Damanpour 1992)/SB7 (Damanpour et al. 1989), and SB3 (Normann and Ramírez 1993)/SB6 (Moore 1993), contrast with the remaining SBs as they are reasonably connected presenting 16, 9 and 6 co-citations, respectively (see Table 2).

Table 2 Citations and co-citations between the SBs of Table 1 (by decreasing order of citations). *Source*: Data from ISI Web of Knowledge and authors' computations based on MS Access queries

Article—by decreasing order of citations		1	2	3	4	5	6	7	8
Kaplan and Norton (1992a, b)	1	1585	2	3	1	0	0	1	0
Trajtenberg (1990)	2	2	522	0	0	2	0	0	0
Normann and Ramírez (1993)	3	3	0	356	1	0	6	0	0
Barras (1986)	4	1	0	1	233	4	0	2	16
Damanpour (1992)	5	0	2	0	4	194	0	9	1
Moore (1993)	6	0	0	6	0	0	146	0	1
Damanpour et al. (1989)	7	1	0	0	2	9	0	106	0
Gadrey et al. (1995)	8	0	0	0	16	1	1	0	90

The reference date for citation data extraction is October 13th, 2014

Identifying the PRs of each SB

According to van Raan (2004), the PR is the first article citing the SB. However, as referred by Li et al. (2014c: 912), "the prince is not necessarily the first cited the Sleeping Beauty". Braun et al. (2010: 196) assert that "[c]andidate Princes were sought for among the first citing articles; they were supposed to be highly or at least fairly cited and to have a considerable number of co-citations with the Sleeping Beauty". Co-citation is also to Li et al. (2014c) and Du and Wu (2016) the stepping stone for uncovering the PRs.

Our procedure for detecting the PRs of the SBs, described in "Steps for identifying the prince (PR) using co-citation patterns" section (and detailed in "Appendix"), following existing studies, relies significantly on PRs' co-citations with the SB. Excluding the cases where 'clusters' of PR exist (SB5: Damanpour 1992; SB6: Moore 1993; and SB7: Damanpour et al. 1989), we left out all those articles with 10 or less co-citations. We further identify two types of PRs: the 'main PR'—the article(s) with a large number of citations and/or co-citations with the SB; and the 'assistant PR'—the articles with more than 10 co-citations with the SB but lower number of citations and/or co-citations (as to compare to the 'main PR').

The exercise undertook demonstrates that finding the PRs of the SBs is a far more complicated and complex endeavor than what the extant literature has been positing. As noted by Du and Wu (2016), and earlier mentioned by Braun et al. (2010), the SBs in analysis needed more than one PR and, in some cases (e.g., SB4: Barras 1986; SB5: Damanpour 1992; SB6: Moore 1993; SB7: Damanpour et al. 1989), one or more clusters of PRs to be awakened. The sleeping intermittency of the SB comes therefore associated to 37 PRs (see Table 3), being 12 classified as 'main princes' (bold references in Table 3).

The majority of PRs were published in well renowned journals—the majority (about 60%) was published in journals with equal or higher impact factor than the journal where the corresponding SB was published. This corroborates the view that the PR has to be a fairly or very important article, often published in the highly ranked journals, that 'frees' the SB from her wasted unnoticed sleep. *Research Policy*, with 4 PRs, *Strategic Management Journal*, with 3 PRs, and *Journal of Marketing, Rand Journal of Economics, Review of Economics and Statistics*, and *Technovation,* with 2 PRs, are responsible for more than 40% of total PRs. This indicates that editors and contributors of these journals are relatively far-sighted and pioneering, being able to accept and/or understand the SBs overlooked contributions (Huang et al. 2015).

It is also interesting to point that about 41% of the PRs are published in journals whose main research areas (e.g., Computer Science, Artificial Intelligence; Computer Science, Information Systems; Operations Research and Management Science, Engineering, Industrial; Engineering, Manufacturing; Public Administration) do not coincide with the research area of the journal where the SB is published (mainly Business and Management). This, to a large extent, reflects the multidisciplinary character of research in innovation studies. The SB5 (Damanpour 1992), SB7 (Damanpour et al. 1989), and SB1 (Kaplan and Norton 1992a, b) present the highest percentage of PRs from outside SB research areas, which can be explained by the fact that they deal with transdisciplinary topics—types of innovation and organizational performance (SB5: Damanpour 1992; SB7: Damanpour et al. 1989), or involve holistic measurements of companies' performance (SB1: Kaplan and Norton 1992a, b).

Resorting to Lange's (2005) and Wang et al.'s (2012) insights, we can explain the delayed scientific recognition of the 8 SBs in analysis by three main groups of reasons/hypotheses: (1) the innovative methods hypothesis—SB1: Kaplan and Norton (1992a, b) and SB2: Trajtenberg (1990); (2) the focus/scientific resistance hypothesis—SB3:

Table 3 Princes (PRs) of the SBs identified (ordered by SB's decreasing number of citations)

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
SB1							
Kaplan, RS; Norton, D.P. (1992), "The balanced scorecard—measures that drive performance"	*Harvard Business Review* IF2015: 2.249, Rank Business: 33/120 (Q2); Rank Management: 46/192 (Q1)	1999 (7 years)	1585 (1987)	Ghalayini, A.M.; Noble, J.S. (1996), "The changing basis of performance measurement", *International Journal of Operations and Production Management*, 16 (8): 63–80	101/31 [2%]	2.252	Management (Q1)
				Ghalayini, A.M., Noble, J.S., Crowe, T.J. (1997), "An integrated dynamic performance measurement system for improving manufacturing competitiveness", *International Journal of Production Economics*, 48 (3): 207–225	71/28 [2%]	2.782	Engineering, Industrial (Q1); Engineering, Manufacturing (Q1); Operations Research and Management Science (Q1)
				Martinsons, M.; Davison, R.; Tse, D. (1999), "The balanced scorecard: a foundation for the strategic management of information systems", *Decision Support Systems* 25 (1): 71–88	**122/42 [3%]**	**2.604**	**Computer Science, Artificial Intelligence (Q1); Computer Science, Information Systems (Q1); Operations Research and Management Science (Q1)**

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
SB2							
Trajtenberg, M. (1990), A penny for your quotes—patent citations and the value of innovation	*Rand Journal of Economics* IF2015: 1.582, Rank Economics: 79/344 (Q1)	1999 (9 years)	522 (619)	Jaffe, A.B.; Trajtenberg, M.; Henderson, R. (1993), "Geographic localization of knowledge spillovers as evidenced by patent citations", *Quarterly Journal of Economics*, 108(3): 577–598	1789/106 [21%]	5.538	Economics (Q1)
				Lerner, J. (1994), "The importance of patent scope—an empirical-analysis", *Rand Journal of Economics*, 25 (2): 319–333	205/57 [11%]	1.582	Economics (Q1)
				Henderson, R; Jaffe, AB; Trajtenberg, M. (1998), "Universities as a source of commercial technology: a detailed analysis of university patenting, 1965–1988", *Review of Economics and Statistics*: 80(1): 119–127	351/43 [8%]	2.979	Economics (Q1); Social Sciences, Mathematical Methods (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Harhoff, D.; Narin, F.; Scherer, F.M.; Vopel, K. (1999), "Citation frequency and the value of patented inventions", *Review of Economics and Statistics:* 81(3): 511–515	**282/142 [27%]**	**2.979**	**Economics (Q1); Social Sciences, Mathematical Methods (Q1)**
				Harhoff, D; Scherer, F.M.; Vopel, K. (2003), "Citations, family size, opposition and the value of patent rights", *Research Policy*: 32 (8): 1343–1363	215/81 [16%]	3.470	Management (Q1); Planning and Development (Q1)
				Hall, B.H.; Jaffe, A; Trajtenberg, M. (2005), "Market value and patent citations", *Rand Journal of Economics*, 36 (1): 16–38	457/162 [31%]	1.582	Economics (Q1)
SB3							
Normann, R; Ramírez, R. (1993), From value chain to value constellation—designing interactive strategy	*Harvard Business Review* IF2015: 2.249, Rank Business: 33/120 (Q2); Rank Management: 46/192 (Q1)	2004 (11 years)	356 (422)	Stabell, C.B.; Fjeldstad, O.D. (1998), "Configuring value for competitive advantage: on chains, shops, and networks", *Strategic Management Journal*: 19 (5): 413–437	237/22 [6%]	3.380	Business (Q1); Management (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Ramirez, R (1999), "Value Co-Production: intellectual origins and implications for practice and research", *Strategic Management Journal*, 20(1): 49–65	176/40 [11%]	3.380	Business (Q1); Management (Q1)
				Vargo, S.L.; Lusch, R.F. (2004), "Evolving to a new dominant logic for marketing", *Journal of Marketing*, 68 (1): 1–17	**1657/102 [29%]**	**3.885**	**Business (Q1)**
				Lusch, R.F.; Vargo, S.L.; O'brien, M. (2007), "Competing through service: insights from service-dominant logic", *Journal of Retailing*, 83 (1): 5–18	228/22 [6%]	2.014	Business (Q2)
SB4							
Barras, R. (1986), Towards a theory of innovation in services	*Research Policy* IF2015: 3.470, Rank Management: 20/192 (Q1); Rank Planning and Development: 2/55 (Q1)	1997–2000 (11–14 years)	233 (282)	Barras, R. (1990), "Interactive innovation in financial and business services—the vanguard of the service revolution", *Research Policy*, 19 (3): 215–237	133/66 [28%]	3.470	Management (Q1); Planning and Development (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Miles, I. (1993), "Services in the new industrial-economy", *Futures,* 25(6): 653–672	68/16 [7%]	1.242	Economics (Q2); Planning and Development (Q2)
				Gallouj, F; Weinstein, O. (1997), "Innovation in services", Research Policy, 26 (4–5): 537–556	**354/85 [36%]**	**3.470**	Management (Q1); Planning and Development (Q1)
				Sundbo, J. (1997), "Management of innovation in services", Service Industries Journal: 17(3): 432–455	**173/33 [14%]**	**0.776**	Management (Q4).

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Coombs, R; Miles, I. (2000), "Innovation, measurement and services: the new problematique", in Coombs, R; Miles, I. (eds.), *Innovation Systems in the Service Economy: Measurement and Case Study Analysis*, Vol.18 of the series Economics of Science, Technology and Innovation, pp. 85–103, Boston; Dordrecht and London: Kluwer Academic	**67/22 [9%]**	**Book Chapter**	Innovation
SB5							
Damanpour, F. (1992), Organizational size and innovation	*Organization Studies* IF2015: 2.798, Rank Management: 31/192 (Q1)	2006 (14 years)	194 (239)	Damanpour, F.L. (1996), "Organizational complexity and innovation: developing and testing multiple contingency models", *Management Science,* 42(5): 693–716	221/24 [12%]	2.741	Operations Research and Management Science (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Chwelos, P; Benbasat, I; Dexter, A.S. (2001), "Research report: empirical test of an EDI adoption model", Information Systems Research, 12(3): 304–321	265/8 [4%]	3.047	Information Science and Library Science (Q1); Management (Q1)
				Zhu, K; Kraemer, K; Xu, S (2003), "Electronic business adoption by European firms: a cross-country assessment of the facilitators and inhibitors", European Journal of Information Systems, 12 (4): 251–268	151/13 [7%]	2.892	Computer Science, Information Systems (Q1)
				Camison-Zornoza, C; Lapiedra-Alcami, R; Segarra-Cipres, M; Boronat-Navarro, M. (2004), "A meta-analysis of innovation and organizational size", *Organization Studies*, 25 (3): 331–361	95/28 [14%]	3.470	Management (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Damanpour, F.; Schneider, M. (2006), "Phases of the adoption of innovation in organizations: effects of environment, organization and top managers", *British Journal of Management,* 17(3): 215–236	135/12 [6%]	2.188	Business (Q2); Management (Q2)
SB6							
Moore, J.F. (1993), Predators and prey—a new ecology of competition	*Harvard Business Review* IF2015: 2.249, Rank Business: 33/120 (Q2); Rank Management: 46/192 (Q1)	2009 (16 years)	146 (233)	*Dodd, S.D. (2002), "Metaphors and meaning—a grounded cultural model of us entrepreneurship", Journal of Business Venturing, 17(5): 519–535*	46/0 [0%]	4.204	Business (Q1)
				Farjoun, M. (2002), "Towards an organic perspective on strategy", Strategic Management Journal, 23(7): 561–594	69/1 [1%]	3.380	Business (Q1); Management (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Kraemer, K.L.; Dedrick, J. (2002), "Strategic use of the internet and e-commerce: cisco systems", Journal of Strategic Information Systems: 11 (1): 5–29	43/1 [1%]	2.595	Computer Science, Information Systems (Q1)
				Rohrbeck, R.; Hölzle, K.; Gemünden, H.G. (2009), "Opening up for competitive advantage — how Deutsche Telekom creates an open innovation ecosystem", R&D Management, 39 (4): 420–430	**23/1 [1%]**	**1.190**	**Business (Q3); Management (Q3)**
				Basole, R.C. (2009), "Visualization of interfirm relations in a converging mobile ecosystem", Journal of Information Technology: 24 (2): 144–159	**24/5 [3%]**	**4.775**	**Computer Science, Information Systems (Q1)**

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Li, Y.-R. (2009), "The technological roadmap of Cisco's business ecosystem", Technovation, 29 (5): 379–386	**22/8 [5%]**	**2.243**	**Engineering, Industrial (Q1); Operations Research and Management Science (Q1)**
SB7							
Damanpour, F; Szabat, K.A.; Evan, W.M. (1989), The relationship between types of innovation and organizational performance	*Journal of Management Studies* IF2015: 4.260, Rank Business: 6/120 (Q1); Rank Management: 12/192 (Q1)	2006 (17 years)	106 (142)	Subramanian, A.; Nilakanta, S. (1996), "Organizational innovativeness: exploring the relationship between organizational determinants of innovation, types of innovations, and measures of organizational performance", *Omega-International Journal of Management Science,* 24 (6): 631–647	132/18 [17%]	3.962	Operations Research and Management Science (Q1)
				Han, J.K.; Kim, N.; Srivastava, R.K. (1998), "Market orientation and organizational performance: is innovation a missing link?", *Journal of Marketing,* 62(4): 30–45	583/31 [29%]	3.885	Business (Q1)

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Walker, R.M. (2006), "Innovation type and diffusion: an empirical analysis of local government", Public Administration, 84 (2): 311–335	**43/4 [4%]**	**1.922**	**Political Science (Q1); Public Administration (Q1)**
				Walker, R.M.; Boyne, G.A. (2006), "Public management reform and organizational performance: an empirical assessment of the UK labour government's public service improvement strategy", Journal of Policy Analysis and Management, 25(2): 371–393	**55/2 [2%]**	**2.329**	**Economics (Q1); Public Administration (Q1)**

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
				Walker, R.M. (2008), "An empirical evaluation of innovation types and organizational and environmental characteristics: towards a configuration framework", Journal of Public Administration Research and Theory, 18(4): 591–615	50/4 [4%]	3.893	Public Administration (Q1)
				Armbruster, H.; Bikfalvi, A.; Kinkel, S.; Lay, G. (2008), "Organizational innovation: the challenge of measuring non-technical innovation in large-scale surveys", Technovation, 28(10): 644–657	57/10 [9%]	2.243	Engineering, Industrial (Q1); Operations Research and Management Science (Q1)
SB8							

Table 3 continued

Sleeping Beauty (SB)	Journal[a]	Awakening year (length of the sleep)[b]	Total citations in October 2014 (in June 2016)	Princes (PRs)	Citations/ co-citations [co-occurrence rate][c]	Journal impact factor (JIF 2015)	Journal area/category (rank/quartile 2015)
Gadrey, J; Gallouj, F and Weinstein, O (1995), New modes of innovation—how services benefit industry	*International Journal of Service Industry Management* [currently published as *Journal of Service Management*] IF2015: 2.233, Rank Management: 49/192 (Q2)	2004 (9 years)	90 (106)	Avlonitis, G.J.; Papastathopoulou, P.G.; Gounaris, S.P. (2001), "An empirically-based typology of product innovativeness for new financial services: success and failure scenarios", *Journal of Product Innovation Management*: 18(5): 324–342	135/27 [30%]	2.086	Engineering, Industrial Q1)
				Drejer, I. (2004), "Identifying innovation in surveys of services: a schumpeterian perspective", *Research Policy*, 33(3): 551–562	**175/26 [29%]**	**3.470**	**Management (Q1); Planning and Development (Q1)**

[a] The impact factor considered was taken from the 2015 Journal Citation Report

[b] Authors' estimation

[c] % Co-citations in SB's total citations. Italic cells represent 'Prince clusters', which jointly act to awake the SB. In the PRs column, the bold reference represents the main prince and the non-bold the 'assistant' princes

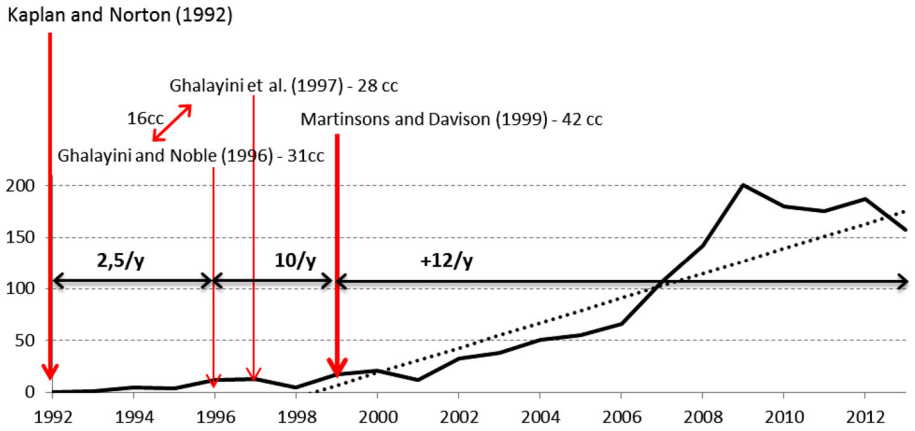


Fig. 3 Citation pattern and PRs of Kaplan and Norton (1992a, b). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source*: Authors

Normann and Ramírez (1993) and SB6: Moore (1993); and (3) the theoretical-relatedness hypothesis—SB4: Barras (1986), SB5: Damanpour (1992), SB7: Damanpour et al. (1989), and SB8: Gadrey et al. (1995).

SB1 (Kaplan and Norton 1992a, b) and SB2 (Trajtenberg 1990) were able to attract scientific attention due to their new and innovative methods/instruments. Their scientific value, however, was only acknowledged when the methods/tools proposed were implemented by other researchers (namely, Martinsons et al. 1999).

Kaplan and Norton (1992a, b) (SB1) introduced a decision support tool, the balanced scorecard, which encompassed a new approach to performance measurement that put strategy and vision at the center and underlined the role of innovation and continuous improvement. Although SB1 was 'slightly kissed' and awaked by Ghalayini and Noble (1996) and Ghalayini et al. (1997), it went dormant afterwards and was reawaked in 1999 by the 'main prince', Martinsons et al. (1999)—see Fig. 3, which developed a balanced scorecard for information systems. Two of the authors of the 'main prince', Maris Martinsons and Robert Davison (City University of Hong Kong) were/are highly influential authors in the area of information systems, with h-indexes of, respectively, 21 and 23, which leveraged new and increasing attention to previously unnoticed research (see Huang et al. 2015).[10]

The case of SB2 (Trajtenberg 1990) is somehow more complex. This SB was seemingly awakened in 1993 and 1994 by a highly and a moderate influential PRs, Jaffe et al. (1789 citations and 106 co-citations) and Lerner (205 citations and 57 co-citations), but it fade away in meantime being later awaked by Harhoff et al. (1999), the 'main PR'—see Fig. 4. Harhoff et al. (1999) provided a large scale application of Trajtenberg's method, estimating the private economic value of 964 inventions made in US and Germany, and proving that the economic value of invention raises with patent citations, as Trajtenberg (1990) earlier established. The scientific attention towards SB2 was further pushed with the contribution of some 'assistants' PRs, most notably Hall et al. (2005). It is also important to highlight

[10] The h-index is based on the highest number of papers included that have had at least the same number of citations. It seeks to measure both the productivity and citation impact of the publications of a given author (Alonso et al. 2009).

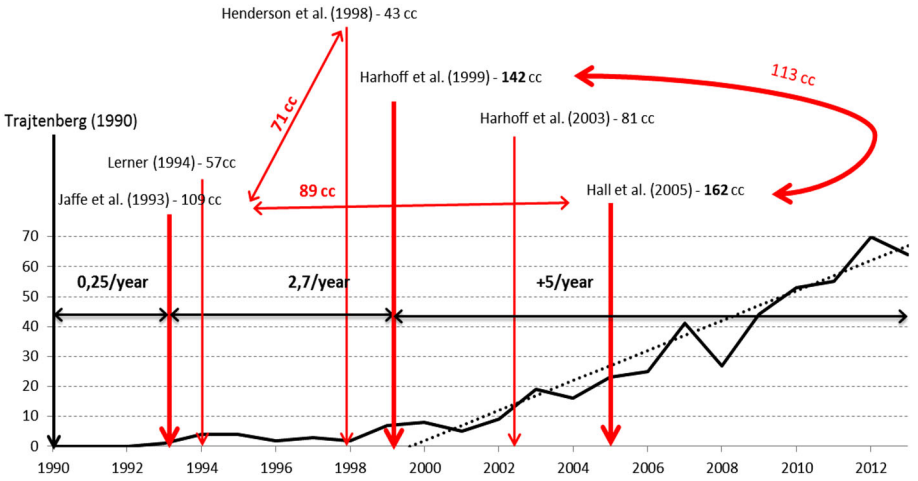


Fig. 4 Citation pattern and PRs of Trajtenberg (1990). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant arrows). *Source*: Authors

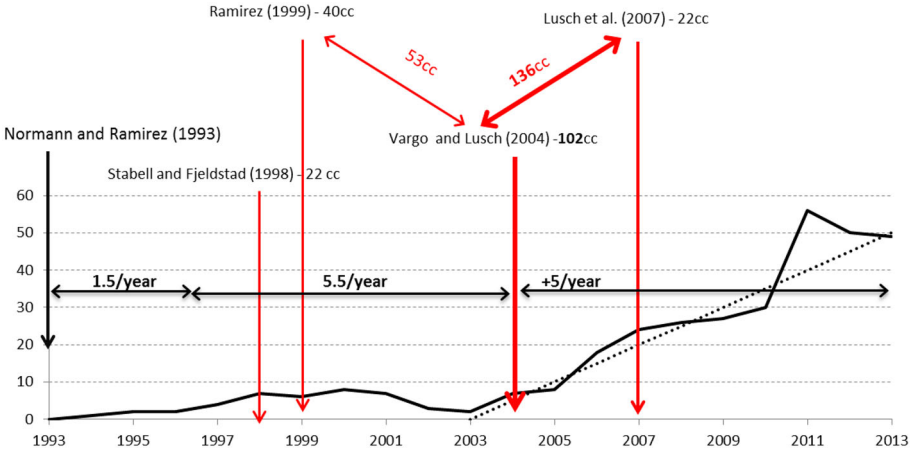


Fig. 5 Citation pattern and PRs of Normann and Ramírez (1993). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source*: Authors

the role of 'h-index princes'—Josh Lerner (Harvard Business School, h-index: 44), Francis Narin (CHI Research/Computer Horizons, US, h-index: 29), Adam Jaffe (Motu Economic and Public Policy Research, New Zealand, h-index: 28), and self-awakening (Manuel Trajtenberg is co-author of 3 'assistant' PRs).

Both Normann and Ramírez (1993) (SB3) and Moore (1993) (SB6) encounter some resistance on the part of the scientific community towards their ideas/discoveries, being dormant (albeit with some intermittencies) for a relatively long period, 11 and 16 years, respectively. They address a similar topic, systemic social innovation and business ecosystems, and challenged the orthodoxy (neoclassical approach).

The PRs of Normann and Ramírez (1993) were far more obvious to encounter than Moore's (1993)—see Figs. 5 and 6. The main PR of Normann and Ramírez (1993) is,

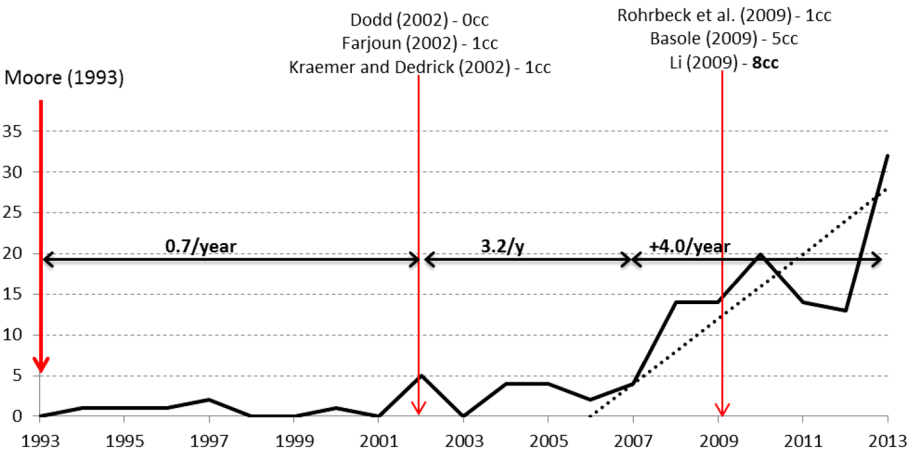


Fig. 6 Citation pattern and PRs of Moore (1993). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source*: Authors

unambiguously, Vargo and Lusch (2004), with 1657 citations and 102 co-citations, published in the well renowned *Journal of Marketing*. Vargo and Lusch (2004) transpose Normann and Ramírez's (1993) ideas to marketing, establishing that the only source of competitive advantage is the ability of a company to conceive the entire value-creating system and make it works. This main PR presents a reasonably high number of co-citations with SB3's 'assistant' PRs, Ramirez (1999) and Lusch et al. (2007), which indicates that the PRs are part of a closely knitted scientific network headed by the 'h-index PR', Robert Lusch (University of Arizona, US, h-index: 28).

Regarding SB6 (Moore 1993) we were not able to identify relevant individual PRs. Although the co-citation threshold (more than 10 co-citations) is not met, Fig. 6 evidence two clusters of PRs, one in 2002 ('assistant' PRs: Dodd 2002; Farjoun 2002; Kraemer and Dedrick 2002) and other in 2009 ('main' PRs: Rohrbeck et al. 2009; Basole 2009; Li 2009). Moore's (1993) path breaking concept of business ecosystems, which comprise a broad community of firms and individuals that add value to a technology standard by supplementing complementary assets to the core product, started to gain scientific acceptance only by mid 2000s when well renowned authors, most notably Kenneth Kraemer (UC Irvine, Paul Merage School of Business, US, h-index: 36), applied business ecosystems concept to real world cases (e.g., Cisco; Deutsch Telecom).

The delayed recognition of the remaining SBs—SB4: Barras (1986), SB5: Damanpour (1992), SB7: Damanpour et al. (1989), and SB8: Gadrey et al. (1995)—is explained by the fact that the topics covered by these articles—innovation in services (SB4: Barras 1986; SB8: Gadrey et al. 1995), and types of innovation and organizations performance, particularly public and nonprofit organizations performance (SB5: Damanpour 1992; SB7: Damanpour et al. 1989) "had no explicit theoretical reference" (Lange 2005: 196), being their scientific content difficult to grasp. As earlier referred both innovation services and in innovation in the public sector were long-standing overlooked topics (Djellal et al. 2013).

Barras (1986) (SB4), to some extent, set out the earlier (weak) bases for a theory of innovation in services, being definitely awaked with the late 1990s/beginning 2000s service-led boom based upon the wide range applications of information technologies (Nardelli 2015). Its main PRs—two journal articles, Gallouj and Weinstein (1997); Sundbo

(1997), and a book chapter, Coombs and Miles (2000)—involve conceptual, empirical and review analyses which "lay the foundations of a theory that can be used to interpret innovation processes in the service sector" (Gallouj and Weinstein (1997: 537), and thoroughly demonstrated that most innovations in services are non-technological "or are developed within a service professional trajectory and the technology is only a means for, or a carrier of, the service innovation" (Sundbo 1997: 452). The chapter by Coombs and Miles is included in an edited book (*Innovation Systems in the Service Economy: Measurement and Case Study Analysis*), provides a solid conceptual framework showing that service firms can be innovative in their own right, even though the process of innovation and the kinds of innovation may be different from those traditionally associated with manufacturing and other primary activities. Although formally published in 2000, such volume was based on a Workshop on Innovation Systems in the Service Economy Local, held in Manchester University in May 1998. In this vein, the three 'main' PRs constitute a cluster of PRs that jointly acted to push forward SB's citation count—see Fig. 7. The 'assistant' PRs (Barras 1990; Miles 1993) burst, though in a non-sustained manner, earlier citations of the SB.

Gadrey et al. (1995), the SB8, is connected with the previous SB (Barras 1986), covering the same topic (innovation in services) and sharing Faiz Gallouj (Universite des Sciences et Technologies de Lille, France), one of the co-authors of SB8 and the 'main' PR of SB2. This SB slept for 9 years being momentarily awaked by the 'assistant' PR, Avlonitis et al. (2001) (135 citations and 27 co-citations), being definitely rouse from sleep in 2004 (see Fig. 8) by Ina Drejer's (Aalborg University, Denmark) review paper, published in *Research Policy*.

The last two SBs—SB5: Damanpour (1992), SB7: Damanpour et al. (1989)—were awaked in the same year (2006) being, together with Moore (1993), the ones with the longest sleeping periods, 14 years (SB5: Damanpour 1992) and 17 years (SB7: Damanpour et al. 1989). The awakening pattern of these SBs (see Figs. 9 and 10) evidence the importance of self-awakening—Fariborz Damanpour (Rutgers, The State University of

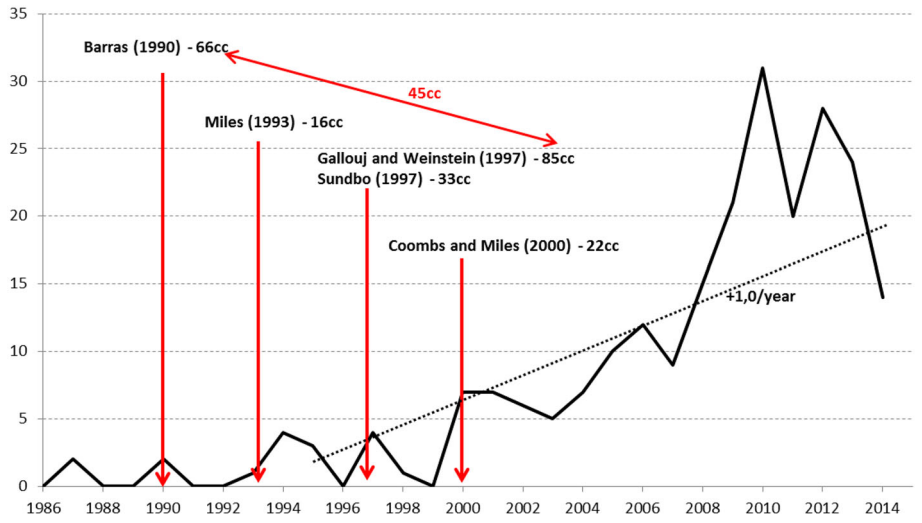


Fig. 7 Citation pattern and PRs of Barras (1986). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source*: Authors

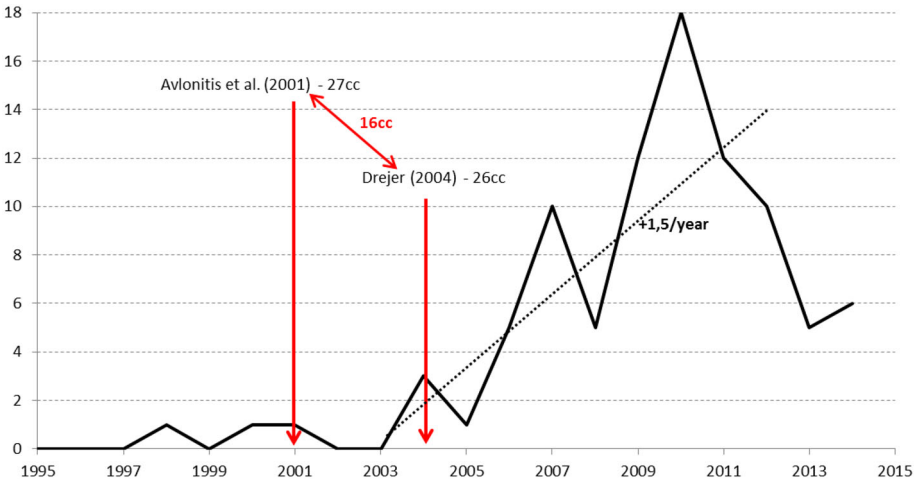


Fig. 8 Citation pattern and PRs of Gadrey et al. (1995). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source:* Authors

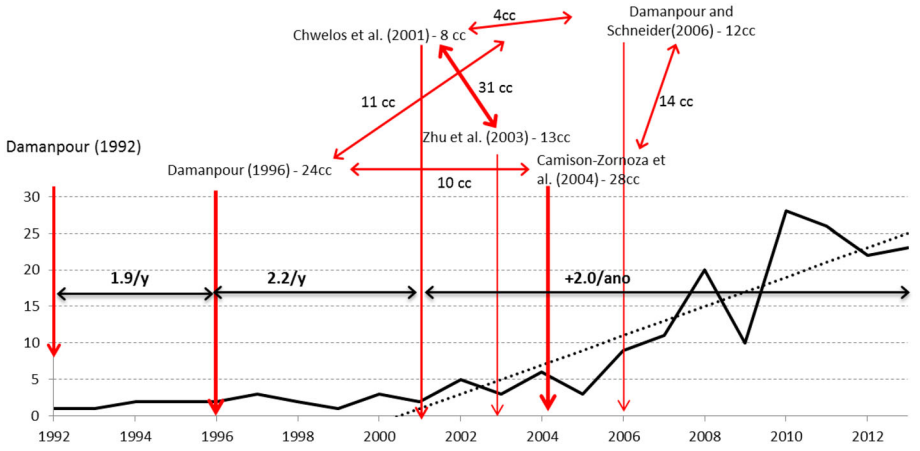


Fig. 9 Citation pattern and PRs of Damanpour (1992). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source*: Authors

New Jersey, US) is co-author of the 'main' PR (Damanpour and Schneider 2006) and author of one 'assistant' PR (Damanpour 1996) of the SB5, and the role of 'h-index' PRs, namely Izak Benbasat (The University of British Columbia, Canada, h-index: 56) and Kenneth Kraemer (UC Irvine, Paul Merage School of Business, US, h-index: 36). These latter authors, due to their highly influential scientific position in their respective research areas, were able to greatly attract new attention to the previously unnoticed SB (see Huang et al. 2015).

The relevance of 'h-index' PRs is also paramount in the awakening process of SB7 (Damanpour et al. 1989). The 'main' PRs cluster includes two articles, published in 2006, (co)authored by Richard Walker (City University of Hong Kong, China, h-index: 29) and

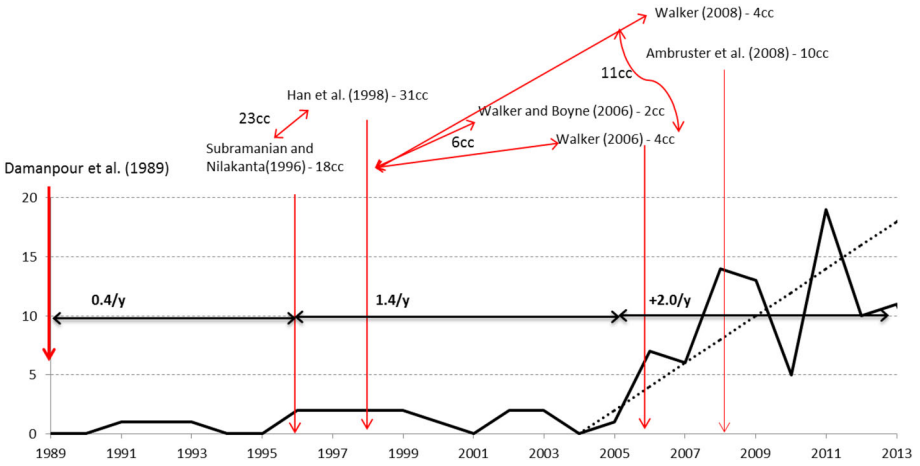


Fig. 10 Citation pattern and PRs of Damanpour et al. (1989). /y, per year; cc, co-citations of the PR with the SB (or the papers indicated by the relevant *arrows*). *Source:* Authors

George Boyne (Cardiff University, UK, h-index: 34). The kiss by these PRs not only decisively rouse from sleep the SB but also pushed it to a new (though related) research area, Public Administration. The earlier 'assistant' PRs (Subramanian and Nilakanta 1996; Han et al. 1998), although being highly cited and presenting a relatively high number of co-citations with the SB, failed to prevent the SB to fall asleep afterwards (see Fig. 10). The most recent 'assistant' PRs (Walker 2008; Armbruster et al. 2008), despite presenting individually very low co-citations with the SB, as a cluster they are likely to have contributed to the most recent upward trend in SB's citations.

Conclusion

In the present study we proposed a new indicator for finding SBs, which comparatively to existing metrics (e.g., van Raan 2004; Ke et al. 2015), has the advantage of identifying the papers that in the future present a higher scientific impact (i.e., receive more citations). However, and in contrast to Ke et al. (2015), our procedure relies on an arbitrary threshold for selecting the effective out of the candidate SBs. Such a threshold (the papers in the top 1% of our metrics) can, nevertheless, be justified on the grounds that SBs are rare and exceptional events in science (Glänzel and Garfield 2004; Lachance and Larivière 2014; Du and Wu 2016). Moreover, according to the recent work Sun et al. (2016), arbitrary thresholds are likely to be more problematic when analyzing SBs from distinct disciplinary areas.

Besides uncovering the SBs in a so far unexplored area—innovation studies, we have contributed to the bibliometric and Scientometrics literature by identifying, for a social science area, the PRs and explaining both the reasons for the delayed recognition and the mechanisms through which the SBs were awaked.

Through our methodological procedures, we were able to uncovered 8 SBs. Thus, as in other areas of knowledge, in innovation studies the potential number of delayed recognition papers is really small (<0.02%). In other words, SBs are a rare and extraordinary occurrence.

The 8 SBs were published in highly renowned journals in the fields of business/management (*Harvard Business Review; Journal of Management Studies; Organization Studies; Research Policy*) and economics (*Rand Journal of Economics*) and were dormant for a minimum of 7 years (Kaplan and Norton 1992a, b) and a maximum of 17 years (Damanpour et al. 1989). These sleeping periods are considerably shorter when compared with the top 15 SBs in Physics, whose sleeping period ranges from 46 to 101 years (Ke et al. 2015). However, considering the length of the sleep of three SBs found in consumer research—13, 15, and 21 years (Baumgartner 2010)—and in *Current Science* papers—6, 7 and 11 years (Kozak 2013), the dormancy periods of our SBs are not very distinct.

The SBs found address four main topics, including new methods/indicators/tools (Kaplan and Norton 1992a, b; Trajtenberg 1990); ecosystem business strategies (Normann and Ramírez 1993; Moore 1993); innovation in services (Barras 1986; Gadrey et al. 1995); and types of innovation and organization performance (Damanpour 1992; Damanpour et al. 1989).

Regarding the PR and the SBs awakening mechanisms, the existing literature is very scarce and usually limited to the description of one or few classical/high profile science papers (e.g., Braun et al. 2010; Li and Ye 2012; Li et al. 2014c; Du and Wu 2016). Thus, the discussion that we can have here is necessarily narrow and incomplete.

We encounter 37 PRs which play distinct roles ('assistant' PRs, 'main' PRs) in the awakening of the 8 SBs. In line with the studies by Li et al. (2014c) and Du and Wu (2016), our SBs needed multiple PRs, and even clusters of PRs, to be rouse from sleep. As Braun et al. (2010: 199) recognized, SBs "are not always chaste as the fairy tale suggests". Indeed, SBs in innovation were kissed, with distinct intensities, and often in simultaneous, by a multitude of PRs.

Although the PRs tend to be highly cited papers, only in 9 cases (25%) the number of citations of the PR overpasses that of the corresponding SB. Using Braun et al.'s (2010) terminology, in innovation studies there is a *female dominance* (SBs citations are, in general, higher than those of their PRs). Similarly to Du and Wu (2016), we found that PRs were, in general, published in multidisciplinary and prominent journals with higher impact and wider scope than the journals publishing the SBs. In particular, prestigious journals such as *Research Policy*, *Strategic Management Journal*, and *Journal of Marketing* revealed a high effectiveness in accepting and/or understanding the SBs overlooked contributions.

The delayed recognition of our 8 SBs could be framed into the hypotheses put forward by Lange (2005) and Wang et al. (2012). Specifically, they were associated to the innovative methods (2 SBs), the focus/scientific resistance (2 SBs), and the theoretical-relatedness hypotheses (4 SBs). Thus, a variety of reasons explain the delayed recognition and the awakening triggers: the scientific value of the SBs is acknowledged when the methods/tools proposed are implemented by other researchers; the increasing acceptance, and even prominence within innovation studies, of alternative/heterodox approaches; and the emergence of conceptual models and explicit theoretical references that are able to rigorously identify SBs scientific substance.

Other awakening triggers include the role of highly influential authors (those with high h-index (see Huang et al. 2015), very important in the awaking process of 6 out of 8 SBs, and self-awakening (Braun et al. 2010; Liu et al. 2015), relevant for half of the SBs.

The discovery of SBs, and their PRs, in the innovation field, as well as the analysis of the reasons for their emergence/awakening, provides us with a distinct and rich overview of the evolution of the literature in the area, offering a better understanding of the reasons for their late recognition and why the 'information sleeps'. Notwithstanding, further work

is necessary to apprehend some particular cases where citation and co-citations patterns do not greatly illuminate the SBs awakening processes.

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Appendix: Detailing the procedure for finding the PRs

To begin the analysis we extracted the citation pattern of Kaplan and Norton (1992a, b), that is, the list of articles that cite Kaplan and Norton (1992a, b) (see Table 4).

In the first step, the candidate PRs shown in the previous list were reduced by excluding all the papers cited 10 or less times. To keep reducing this list, we had to keep using the citation pattern as a form of measurement.

The next step consisted in repeating the download process but now for articles citing the potential PRs. We were thus able to obtain the data needed to count the co-citations. In the two lists of articles [one with articles citing Kaplan and Norton (1992a, b), and the other with articles citing potential PRs, using in this example Martinsons and Davison (2007)] we counted the items that were simultaneously on both lists, the co-citations (see Table 5).

The literature defines the PR as an article that cites the SB in the year that the SB begins to be awakened (van Raan 2004). Van Raan (2004) found an extreme case with the longest sleeping period in his research, in which the SB was cited by its first PR after 10 years of dormancy. Therefore, the analysis could be reduced to the year in which the awakening of the SB occurs. However, as a priori we do not have solid information to guarantee that this assumption is always confirmed, we needed to study as potential PRs all the articles citing the SB with some impact in the literature (more than 10 citations since their publication to the present).

Table 4 Part of the list of articles citing Kaplan and Norton (1992a, b), the SB. *Source*: Authors

Paper	Times cited	Potential PR
Brown and Mitchell (1993)	28	Yes
Griffith (1994)	16	Yes
Hiltrop and Despres (1994)	6	No
Powell (1994)	2	No
Nohria and Berkley (1994)	8	No
Griffith et al. (1994)	3	No
Hackman and Wageman (1995)	443	Yes
Noci (1996)	4	No
Longbottom and Zairi (1996)	4	No
Ghalayini and Noble (1996)	101	Yes
Peterson and Niels (1997)	0	No
Sarkis et al. (1997)	12	Yes
Burke (1997)	7	No
Ghalayini et al. (1997)	71	Yes
Levinthal and Warglien (1999)	98	Yes
Martinsons and Davison (2007)	122	Yes

The reference date for citation data extraction is October 13th, 2014

Table 5 Part of the list of articles citing Kaplan and Norton (1992a, b) or Martinsons and Davison (2007) *Source*: Authors

Paper	Cites the SB	Cites the PR	Co-citation
Bhagwat and Sharma (2007)	Yes	Yes	1
Ren (2008)	Yes	No	0
Davison and Ou (2007)	Yes	Yes	1

The reference date for citation data extraction is October 13th, 2014

Table 6 Potential PRs of Kaplan and Norton (1992a, b) *Source*: Authors

Paper	Source title	Journal impact factor (2015)	Times cited	Co-citations	Potential PR
Brown and Mitchell (1993)	Human Relations	2.619	28	3	No
Griffith (1994)	Hospital and Health Services Administration (currently published as Journal of Healthcare Management)	–	16	6	No
Hackman and Wageman (1995)	Administrative Science Quarterly	5.316	443	10	No
Ghalayini and Noble (1996)	International Journal of Operations and Production Management	2.252	101	43	Yes
Sarkis et al. (1997)	International Journal of Production Economics	2.782	12	0	No
Ghalayini et al.(1997)	International Journal of Production Economics	2.782	71	38	Yes
Levinthal and Warglien 1999)	Organization Science	3.360	98	0	No
Martinsons et al. (1999)	Decision Support Systems	2.604	122	50	Yes

The reference date for citation data extraction is October 13th, 2014

With the two lists, the next phase was based on the count of the co-citations. To identify the co-citations we first used Excel to build the data table, and after importing the Excel table to Access, we used an Access query. The Excel table included information regarding all the articles we were going to analyze (the 8 articles identified in Table 6 as potential PRs marked with a *yes* in the column 'Potential PR', plus the SB) considering only 2 columns. In the first column we placed a code that identified the article cited and in the second column we placed the name of the article that cites that article. Considering the year(s) in which the awakening of the SB occurs, we removed those papers with 10 or less co-citations.

Taking into consideration the potential PRs with the highest citations and a valid number of co-citations to be considered a PR (more than 10 co-citations), the list of Kaplan and Norton's (1992a, b) potential PRs was reduced to 3 articles (which are included in Table 3 of the main text).

It is important to note that for SB6: Moore(1993) and, in part, for SB 7: Damanpour et al. (1989), adopting such procedure did not permit to find the proper PRs. Indeed, individually the co-citations between the SB and the candidate PRs were below 10. However, as some of these candidate PRs were published in the same/nearby year, we considered that these formed a 'PR cluster' which was able, as a whole, to awake up the SB.

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* (**) Indicates an article that is a Sleeping Beauty (Prince).

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