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Between expectations and outcomes: Technology adopters' narratives and technology discourse dynamics

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A B S T R A C T

Expectations propel the evolution of emerging technologies, yet existing research generally assumes that expectations are gradually displaced by concrete outcomes as technologies mature and become widely accepted. We revisit this assumption by examining how technology adopters' temporal framings of technology performance, their expressions of concrete outcomes of technology adoption, and the broader technology discourse reflected in trade-press coverage relate to one another over time. We illuminate these patterns by tracing 21 years (2002−2022) of radio-frequency identification (RFID) adoption and analysing adopters' statements in 407 case stories published in The RFID Journal, coupled with a longitudinal corpus of trade-press coverage from the same period. Manual coding of adopters' expressions of concrete realised benefits and challenges in the case stories is combined with a purpose-built dictionary that detects five temporal positions in adopters' framings of RFID performance. We find that associations between concrete outcomes and temporal framings are selective and stage-dependent. Concrete outcomes do not simply replace expectations, instead, they become associated with specific temporal framings over time. We also find that adopters' temporal framings are associated with trade-press coverage in stage-specific ways that change over time, often amplifying but also sometimes tempering broader attention to RFID. We contribute to research on technology framing and expectations dynamics by foregrounding adopters as co-constructors of technology discourse, challenging the displacement assumption with a stage-sensitive explanation of expectation–outcome dynamics, and introducing a replicable, dictionary-based approach for large-scale analysis of temporal framings in technology narratives.

1. Introduction

In an increasingly technology-driven world, organisational leaders routinely face decisions about which technologies to invest in, when to invest, and in which business areas. These decisions are especially challenging for emerging technologies, which are characterised by radical novelty, rapid growth, strong impact, consistency and considerable uncertainty and ambiguity (Rotolo et al., 2015). Under such conditions, technology actors must make decisions about technologies before their performance is fully knowable, drawing not only on their own experience but also on technology discourse. We understand technology discourse as the language, rhetoric, and narratives through which technology actors, including vendors, adopters, regulators, or even the public at large, collectively describe a technology and its performance (Hsu et al., 2014; Swanson and Ramiller, 1997). Technology discourse both holds and shapes technology actors' interpretations of an emergent technology's business value, the artefacts involved, and the organisational practices associated with its applications (Swanson and Ramiller, 1997). These interpretations are critical inputs into actors' decisions to pursue a particular technology, whether vendors selling or producers developing novel technology applications (Wang and Swanson, 2007), or adopters implementing new technologies into their processes (Parameswaean et al., 2023). As technology discourse changes over time, so do actors' interpretations of the technology (Bojovic, 2022; Hoppmann et al., 2020; Swanson and Ramiller, 1997). Thus, understanding how actors' interpretations of an emergent technology evolve and how they do so in relation to changes in technology discourse over time is important for capturing the shifts in technology investment decisions that underpin the patterns of technology change (Hsu et al., 2014; Swanson and Ramiller, 1997).

Research conceptualises actors' interpretations of a technology as *framing*, which involves the purposeful use of language to construct and negotiate meanings (Cornelissen and Werner, 2014). Studies have used framing to examine, for instance, the collective interpretations of an emergent technology reflecting industry actors' expectations of its value and application within a given sector (Kaplan and Tripsas, 2008; Swanson and Ramiller, 1997), or producers' expectations regarding different aspects of technology performance, such as the temporal position from which performance is discussed (e.g., present or future) (Hoppmann et al., 2020) and the specificity of application (narrow or

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broad) (Bojovic, 2022). Framing captures both actors' own interpretations of an emergent technology and, when deployed purposefully, their efforts to influence others' interpretations (Cornelissen and Werner, 2014; Kaplan, 2008; Kaplan and Tripsas, 2008; Orlikowski and Gash, 1994). As such, framing is related not only to actors' own expectations of technology value or performance, but also to their interests in relation to a particular technology (Kaplan, 2008).

Most framing research has focused on technology producers (Benner and Tripsas, 2012; Kirkels, 2016), powerful institutional actors such as regulators (Alkemade and Suurs, 2012), and the broader community (Kriechbaum et al., 2018; Ruef and Markard, 2010), rather than on technology adopters. However, the expectations and interests of the heterogeneous actors involved in the emergence of a new technology are not necessarily aligned (Swanson and Ramiller, 1997). For instance, regulators aim to safeguard the public by minimising harmful outcomes, whereas technology producers focus on improving a particular technology and selling it to outcompete alternatives (Keisler et al., 2021). Conversely, adopters are concerned with the value of alternative technologies, the trade-off between the value of early adoption versus waiting for concrete information on technology performance (Cabral and Dezso, 2008), and the actual benefits relative to the costs associated with technology adoption (Baldwin and Lin, 2002). While producers are committed to a technology from the outset, adopters align themselves with a particular technology only after making significant commitments that bind them to its current and future versions (Cabral and Dezso, 2008). This suggests that, particularly for emergent (rather than established) technologies, adopters are likely to frame their expectations about technology performance differently from producers. Furthermore, adopters and their interpretations are as critical as producers and regulators in shaping technology evolution (Kaplan and Tripsas, 2008). Consequently, understanding the dynamics of adopters' framings is important, as we cannot assume that their framings follow the same patterns as those of other technology actors. Only by accounting for adopters can we fully examine the evolution of technology discourse and the patterns of technology change this discourse may support.

Framings are an integral part of the discourse around an emergent technology, both shaping the discourse as they contribute to the collective expectations around a new technology (Swanson and Ramiller, 1997), and being shaped by it, as they reflect the efforts of technology actors to influence how others perceive and evaluate that technology (Alkemade and Suurs, 2012; Wen, 2024). As well as capturing actors' efforts to frame their expectations of technology performance, technology discourse also captures adopters' expressions of concrete outcomes from actual technology applications, including concrete benefits and concrete challenges. Studies find that performance expectations and concrete outcomes evolve differently (Shi and Herniman, 2023), with expectations following a hype-disappointment cycle that mirrors the rise and decline in attention surrounding new technologies (Fenn and Raskino, 2008; Kirkels, 2016), and concrete outcomes following an S-curve, reflecting the gradual accumulation of knowledge about new technologies (Fenn and Raskino, 2008; Foster, 1986). Heuristics such as the Gartner Hype Cycle combine these dynamics and are widely used in research and practice to explain technology evolution in terms of changes in a technology's visibility over time, as reflected in media coverage dynamics (Dedehayir and Steinert, 2016; Fenn and Raskino, 2008; van Lente et al., 2013).

Existing research generally assumes a displacement relationship between expectations of technology performance and concrete outcomes of adoption during technology evolution to explain changes in a technology's visibility within technology discourse and media coverage dynamics (Dedehayir and Steinert, 2016; Fenn and Raskino, 2008; van Lente et al., 2013). As a new technology emerges, uncertainty is high and concrete applications are scarce, meaning actors rely on expectations of future performance to guide investment and adoption (Fenn and Raskino, 2008; van Lente et al., 2013). Over time, as the technology evolves and applications proliferate, evidence of concrete outcomes realised by adopters accumulates, eventually replacing expectations in driving technology visibility in media coverage (Dedehayir and Steinert, 2016). However, recent studies investigating the dynamics of heterogeneous expectations and framings find that they persist in technology media coverage throughout technology evolution, though with varying intensities (Hoppmann et al., 2020; Kriechbaum et al., 2021). This suggests that, over time, the relationship between actors' framings of technology performance and their expressions of concrete outcomes, and the role of both framings and concrete outcomes in driving technology discourse, may differ from the generalised displacement pattern suggested by most existing research (Shi and Herniman, 2023). Furthermore, because prior work has paid limited attention to adopters, we do not know whether the presumed displacement from framings and expectations to concrete outcomes holds when the analysis foregrounds actors whose concrete implementation experience is directly at stake.

Consequently, we set out to investigate the relationship between adopters' temporal framings of an emerging technology's performance and their expressions of concrete outcomes, as the technology evolves. We consider a specific dimension of technology framing, namely, adopters' *temporal framings* of technology performance, which refer to the time frame relative to which performance is discussed (Hoppmann et al., 2020). Temporal framings are especially relevant to our study for two reasons. First, they show how actors locate technology performance across different time horizons, allowing us to observe how expectations and concrete outcomes are discursively related as the technology evolves. Second, they are critical for adopters, who need to continually justify investments over different time horizons, such as pilot implementations against future expectations (Blut et al., 2022), and current outcomes against prior goals (Bunduchi et al., 2011). We then examine how these adopter narratives, and the temporal framings they contain, vary in relation to broader trade-press coverage dynamics to assess whether adopter framings track, diverge from, or help explain evolutionary patterns of technology change as reflected in trade-press coverage over time. Our research questions are as follows:

RQ1: How are adopters' expressions of the concrete outcomes of adopting an emerging technology associated with adopters' temporal framings of technology performance over time?

RQ2: How are adopters' temporal framings of technology performance associated with trade-press coverage dynamics over time?

We examine these questions by analysing longitudinal data about RFID technology, a relatively recent emerging technology whose commercial evolution unfolded over a sufficiently long period to make changes in temporal framings,[1] concrete outcomes, and technology discourse dynamics in the trade press observable over time (Bunduchi et al., 2011; Dew, 2006; Jung and Lee, 2015).

This study advances research on technology framing and expectations dynamics by foregrounding technology adopters rather than producers and offering a stage-sensitive, adopter-centred account of how expectations reflected in technology framings and expressions of concrete outcomes, remain intertwined as technologies move from emergence towards wider use. First, by tracing associations among adopters' temporal framings, their expressions of concrete outcomes, and trade-press coverage across the Gartner Hype Cycle stages, the study develops a stage-sensitive view of how adopters' expectations and concrete outcomes co-evolve rather than simply succeeding one another. Rather than supporting a simple displacement model in which concrete evidence replaces expectations as technologies mature (Dew, 2006; Foster, 1986; Wen, 2024), the findings reveal selective, stage-dependent relationships in which adopters' temporal framings become re-anchored in concrete adoption experiences, especially through expressed challenges and future-oriented framings. Second, by foregrounding adopters, the

[1] For improved readability, we use *temporal framings* as shorthand for *temporal framings of technology performance*.

study contributes to research on how technology framings, specifically adopters' framings, are constructed. Adding to existing research that explains framing as a cognitive (Kaplan and Tripsas, 2008; Orlikowski and Gash, 1994), political (Kaplan, 2008), or legitimation (Bojovic, 2022; Wen, 2024) process, our findings underscore how adopters' framings are also shaped by learning from other adopters' concrete experiences, as reflected in the accumulating expressions of concrete benefits and challenges over time. This shifts adopters from being treated mainly as recipients of technology expectations or sources of later-stage concrete evidence to being understood as co-constructors of technology discourse. Finally, methodologically, the study pioneers a dictionary-based approach that enables longitudinal analysis of adopters' temporal framings in technology narratives, offering a replicable template for expectation research on other emerging technologies. Together, these contributions advance our understanding of the co-evolution of adopters' expectations, their expressions of concrete outcomes, and technology discourse during technology evolution.

2. Theoretical background

To investigate our research questions, we draw on the sociology of expectations literature to examine the dynamics of actors' technology expectations and their relationships with expressions of concrete technology outcomes and the broader technology discourse. We also draw on the literature on technology framing to conceptualise actors' efforts to frame these expectations and their role in driving technology evolution.

2.1. Technology expectations, concrete outcomes, and technology discourse dynamics

Collectively held expectations about a technology, as reflected in technology discourse in the media, significantly shape the trajectory of novel technologies (Borup et al., 2006; Kriechbaum et al., 2021; van Lente et al., 2013). Expectations help organise action by attracting attention, mobilising resources, coordinating actors, and legitimating emerging technology evolution trajectories (Borup et al., 2006; Brown and Michael, 2003), even when technology outcomes remain uncertain. In this sense, expectations can be viewed as performative, since they can contribute to the conditions under which particular technology evolution paths become credible and actionable. Technology discourse both reflects these expectations and, through framing efforts, influences technology evolution (Hsu et al., 2014; Swanson and Ramiller, 1997).

The Gartner Hype Cycle (Borup et al., 2006; Fenn and Raskino, 2008; Shi and Herniman, 2023) is a commonly used heuristic that captures the dynamics of technology expectations, in which expectations rise rapidly to highly inflated levels and then collapse when reality fails to meet them (Bojovic, 2022). Thus, the Gartner Hype Cycle is a useful heuristic for periodising changes in technology visibility in the media over time and for explaining the role that expectations versus concrete outcomes play in these changes.

Technologies are inherently uncertain during their emergence. The form they will ultimately take, the complementary capabilities required for adoption, the criteria for assessing performance, and the pace and scope of eventual evolution are all ambiguous at the outset (Nelson and Winter, 1977; Rosenberg, 1996; Rotolo et al., 2015). In the absence of reliable information from real-world applications, producers, adopters, and regulators of emerging technologies base investment decisions on expectations about future performance rather than on evidence of concrete outcomes (Alkemade and Suurs, 2012; Borup et al., 2006). As a technology matures and its applications diffuse across adopters, knowledge about the opportunities it offers, the costs of implementation, and the value gained from specific applications accumulates within an industry (Breschi et al., 2000). This growing knowledge of concrete outcomes from technology applications is often understood to gradually displace expectations in driving technology investments and the ensuing patterns of technology evolution (Shi and Herniman, 2023). We consider such *concrete outcomes* to fall into two broad categories: benefits and costs or challenges (Bunduchi et al., 2011). *Benefits* are concrete positive outcomes from technology applications, such as operational improvements, efficiency gains, or enhanced visibility achieved through implementation. *Challenges* are concrete difficulties, costs, barriers, or problems encountered in applying the technology to business operations (Smart et al., 2010).

The Gartner Hype Cycle is useful here because it links the changing interplay between expectations and concrete outcomes to broader patterns of technology evolution over time, as reflected in media coverage. Media coverage is typically viewed as an indicator of a technology's visibility within broader technology discourse (Dedehayir and Steinert, 2016; Fenn and Raskino, 2008), whether societal, as seen in mass media (Kriechbaum et al., 2018, 2021), or at the industry level, as in our case, as captured in trade-press coverage.

According to the Gartner Hype Cycle heuristic, media attention following an initial technological breakthrough triggers a peak of inflated expectations about the emerging technology. This prompts rapid imitation despite scant evidence of concrete outcomes indicative of actual technology performance (stage 1). When those expectations go unmet, scepticism takes over and is amplified by the media. This triggers a trough of disillusionment, reducing the technology's visibility and slowing its evolution (stage 2). Over time, applications of the technology begin to yield demonstrable benefits, shifting attention to indicators of concrete outcomes and gradually reviving the technology's visibility and adoption along a slope of enlightenment (stage 3). The slope eventually levels off at the plateau of productivity (stage 4) as the technology matures, its performance becomes well understood, and documented concrete outcomes accumulate within the industry (van Lente et al., 2013). The Gartner Hype Cycle literature treats technology expectations as decisive in the early stages and assumes that accumulating information about concrete outcomes gradually takes over (Dedehayir and Steinert, 2016; Fenn and Raskino, 2008; van Lente et al., 2013). Yet this literature says little about how these expectations interact with emerging evidence of concrete outcomes and how that interaction shapes the overall dynamics of the technology discourse.

In general, sociology of expectations research conceptualises expectations as relating to the future capabilities of technologies (Borup et al., 2006), particularly performance (Alkemade and Suurs, 2012). Different types of performance expectations can be distinguished by criteria such as period, direction of impact, specificity, and cognitive basis (Alkemade and Suurs, 2012; Kirkels, 2016; Kriechbaum et al., 2018; Ruef and Markard, 2010; Shi and Herniman, 2023; van Lente et al., 2013). These expectations exhibit different dynamics. For instance, Kriechbaum et al. (Kriechbaum et al., 2018; Kriechbaum et al., 2021) show that societal-level expectations, rather than project- or technology-level expectations, largely explain the technology evolution patterns of different renewable energies in Germany over time, as reflected in the public technology discourse. Shi and Herniman (2023) find that emotional expectations drive technology evolution early on, replaced by logical expectations in later stages. These findings imply that some expectations may shape technology evolution well beyond the early stages, unlike what is posited by the Gartner Hype Cycle literature (Fenn and Raskino, 2008). Framing research (Bojovic, 2022; Hoppmann et al., 2020; Wen, 2024) extends this insight by examining how technology actors articulate heterogeneous expectations about a technology's future capabilities to steer its evolution.

2.2. Technology framing

Expectations are constructed and contested in discursive arenas (Hsu et al., 2014; van Lente et al., 2013), as social actors use language and narratives (Goffman, 1974) to frame an emerging technology. Such framing reflects both actors' cognitive understanding of what a technology is and what it promises to do (Kaplan and Tripsas, 2008), and their efforts to influence how others interpret the technology and its

promise (Kaplan, 2008). Framing is defined as "*the ways in which individuals use language […] in context either to reinforce existing interpretive frames or to call new frames into being*" (Cornelissen and Werner, 2014, pg. 18-19), with frames representing "*principles of organization which govern the subjective meanings we assign to social events*" (Goffman, 1974, pg. 11).

Framing of a technology is both cognitive and symbolic[2] (Goffman, 1974; Kaplan, 2008), involving interpretative processes through which actors draw on their assumptions, knowledge, and experiences to make sense of a new technology (Kaplan and Tripsas, 2008; Orlikowski and Gash, 1994), and social discursive efforts through which actors use language, symbols, and narratives to construct meaning and persuade others about that technology (Cornelissen and Werner, 2014; Goffman, 1974; Orlikowski and Gash, 1994). We focus on the social discursive aspect, which emphasises the role of discourse in shaping the evolution of emergent technologies (Hsu et al., 2014).

While expectations research mostly focuses on capturing the dynamics of the public technology discourse as reflected in the media (Alkemade and Suurs, 2012; Kriechbaum et al., 2018; Ruef and Markard, 2010), framing research investigates the discourse of specific groups of technology actors, generally producers, to capture their efforts to construct and negotiate interpretations of a new technology and, in doing so, shape technology dynamics (Bojovic, 2022; Hoppmann et al., 2020; Kaplan, 2008). Prior research in the fields of technology, organisation, and strategy shows that framing drives technology actors' decisions to buy (Bojovic, 2022), develop (Kaplan, 2008), invest in (Hoppmann et al., 2020), and support favourable regulation for a technology (Wen, 2024). Such research has proposed socio-cognitive models of technology evolution, which explain technology trajectories as driven by the dynamics of and interactions among the framing efforts of technology actors, whether producers, adopters, or regulators, over time (Kaplan and Tripsas, 2008). Such models describe how organisational actors, mostly technology producers, engage in discursive efforts to construct and negotiate specific meanings around a new technology to stimulate its adoption, and how such efforts influence technology evolution patterns (Hoppmann et al., 2020; Hsu et al., 2014).

Similar to the sociology of expectations, framing research also documents substantial heterogeneity in the frames technology producers deploy to drive technology adoption over time, for instance depending on their degree of resonance with the target audience, e.g., broad (outside applications), narrow (within application) and transversal (across applications) (Bojovic, 2022; Hsu et al., 2014; Kaplan, 2008; Wen, 2024), and by their temporal position, reflecting the point in time to which technology performance is referred in discourse, i.e. *potential temporal framing of performance* (performance framed as possible at an undefined point in the future), *prospect temporal framing of performance* (expected performance at a specific point in time in the future), *present temporal framing of performance* (performance framed as currently realised or observable in ongoing use), and *progress temporal framing of performance* (performance framed in relation to changes vis-a-vis the past, emphasising what has changed over time) (Hoppmann et al., 2020).

Different frames are more prevalent at different times during technology evolution. For example, producers emphasise potential temporal framings of performance in the earliest stage, referring to technology performance in the indefinite future, when uncertainty is high and applied experience scarce (Rotolo et al., 2015), and shift to present temporal framing of performance as the technology matures and applications abound (Hoppmann et al., 2020). The impact of framings can thus endure well beyond the early stages of technology evolution, when performance expectations are hyped, challenging accounts in technology expectations and hype cycle research that confine the influence of expectations to the initial stages of technology evolution (Shi and Herniman, 2023).

Despite research indicating that framing varies over time as technology evolves, there is scant attention to the connections between expectations framing and concrete technology outcomes. Framing research, which generally focuses on technology producers and their interests, depicts framing either as a political act to mobilise commitment to a preferred technology (Kaplan, 2008) or as legitimacy-seeking efforts to establish resonance with specific audiences (Bojovic, 2022; Wen, 2024). However, whether considering producers or adopters, indicators of concrete outcomes of technology matter, as producers are interested not only in selling a technology, but also in making technology improvements, while adopters make investment decisions by considering the benefits of delaying adoption to wait for concrete information (Cabral and Dezso, 2008), and by balancing the actual benefits and costs associated with technology adoption realised during implementation projects (Baldwin and Lin, 2002; Bunduchi et al., 2011). Since framing also reflects actors' interests (Kaplan, 2008), and such interests also involve the concrete outcomes of technology adoption, new information about concrete outcomes can be expected to influence how actors frame their expectations about what technology is and what it can do. While this information may be incomplete and difficult to assess when a technology emerges (Nelson and Winter, 1977; Rotolo et al., 2015), it is not entirely absent, as lead users and early adopters generate evidence through piloting (Bunduchi et al., 2011). Moreover, specific framing types continue to appear in later stages of a technology evolution (Hoppmann et al., 2020), when detailed knowledge of performance is abundant (Breschi et al., 2000), suggesting that framing may remain related to concrete outcomes rather than simply being displaced by them. These observations motivate our first research question.

Technology producers are but one group of actors shaping the technology discourse that underpins technology evolution. The discourse involves both producers and adopters talking about a new technology, trying to make sense of its value and applications within an industry (Swanson and Ramiller, 1997), and fuelling the collective technology discourse as reflected in the media (Kaplan and Tripsas, 2008; van Lente et al., 2013). For example, Walmart and the US Department of Defence, both major early RFID adopters, were instrumental in encouraging RFID development through their RFID mandates, hyping early industry-wide expectations, and accelerating RFID uptake (Bunduchi et al., 2011). Thus, adopters' framing influences collective expectations, but differently from producers' framing. For instance, while adopters are initially indifferent to which technology they invest in and tend to consider alternative options until they commit to a technology, producers are dedicated from the outset to the particular

[2] Framing research takes either a cognitive or a social-discursive approach (Cornelissen and Werner, 2014). Cognitive approaches focus on micro-level analysis (Cornelissen and Werner, 2014), foregrounding how actors' prior knowledge and expectations filter environmental cues and guide actions with emerging technologies (Kaplan and Tripsas, 2008; Orlikowski and Gash, 1994). Social-discursive approaches take a *meso* perspective, emphasising how organisational actors construct meaning through narratives to persuade others (Cornelissen and Werner, 2014; Goffman, 1974). Both see framing as a strategic activity involving the use of language to influence others' beliefs (Cornelissen and Werner, 2014). The first focuses on technology discourse as reflecting people's sense-making efforts that shape their actions towards the technology (Kaplan and Tripsas, 2008; Orlikowski and Gash, 1994), whereas the second focuses on discourse as reflecting people's efforts to use language and narratives to construct meaning and persuade other stakeholders (Goffman, 1974). Both view discourse as related to how people attribute meaning to a technology, either via cognitive interpretation or social persuasion (Cornelissen and Werner, 2014). Our research targets organisational adopters, specifically their discursive efforts as reflected in journalists' coverage in the trade press and in the direct statements included in The RFID Journal case studies, focusing on adopters' narratives that form the discourse around RFID technology rather than individual sense-making. Hence, we adopt the meso-level, social-discursive lens. This approach, common in strategic framing research, often relies on public statements, e.g., vendors' PR releases or mass media (Hoppmann et al., 2020; Kriechbaum et al., 2018; Kriechbaum et al., 2021; Ruef and Markard, 2010), to capture social persuasive efforts.

technology they sell (Cabral and Dezso, 2008). This suggests that adopters' framing may follow different dynamics as technology evolves over time compared with producer framing. However, research either concentrates on collective expectations as reflected by mass media (Kriechbaum et al., 2021) or on technology producers' framing (Bojovic, 2022; Hoppmann et al., 2020), neither connecting the two nor exploring framing by technology adopters and its influence on technology discourse evolution. This motivates our second research question.

To investigate our research questions, we focus on the temporal framing of technology performance (Hoppmann et al., 2020). While prior research identifies several framing dimensions, such as specificity (Kriechbaum et al., 2018; Wen, 2024), resonance with audiences (Bojovic, 2022), and direction of impact (Kriechbaum et al., 2018; Kriechbaum et al., 2021), for technology adopters, these dimensions are less useful than temporal framings for explaining variations in adopter framing within implementation narratives over time. Adopters typically engage with technologies through specific implementation projects and, once committed to adoption, are more likely to frame technology performance in relation to a defined application context, a narrower set of organisational audiences, and generally positive expected outcomes (Alkemade and Suurs, 2012; Bojovic, 2022). Once a firm allocates resources to a concrete implementation project that fits its strategic objectives (Henderson and Venkatraman, 1999), its expectations are typically positive (Blut et al., 2022) and already specific to the targeted process (Blut et al., 2022). What remains uncertain is whether adopters position technology performance across time horizons as a future possibility, a near-term prospect, a present reality, a past expectation, or an accumulated progress. Adopters must weigh immediate returns from a pilot implementation against potential future gains from scaling the technology throughout the organisation (Blut et al., 2022). Accordingly, temporal framing provides the most analytically useful lens for examining variation in how adopters frame their expectations about a technology over time.

3. Research design

3.1. Empirical context

We conducted a longitudinal examination of RFID adoption from 2002 to 2022. RFID is a suitable empirical context for three reasons. First, it aligns with our definition of an emerging technology (Rotolo et al., 2015). In the early 2000s, RFID was a relatively novel technology characterised by rapid growth (Ngai et al., 2008). By the 2010s, RFID had demonstrated strong impact across a wide range of applications, yet uncertainty remained due to ongoing technical issues, uncertain effectiveness, and high ambiguity stemming from limited transparency and poor understanding of associated organisational practices (Jung and Lee, 2015; Reyes et al., 2016). During this period, the technology also remained broadly consistent in its underlying architecture (e.g., tags, readers, and middleware) (Sarac et al., 2010).

Second, RFID offers a rich context for examining discourse and evolution over time. The late 1990s and early 2000s saw prominent technology actors rally around RFID's grand promises of "frictionless" traceability, only for some key actors to back away in the ensuing decade (e.g., Walmart and the US Department of Defence RFID mandates) (Reyes et al., 2016). By the mid-2010s, RFID adoption spanned multiple sectors, including retail, logistics, healthcare, and aerospace (Jung and Lee, 2015), producing a rich longitudinal trail of adopter narratives, trade-press coverage, and performance information.

Finally, RFID's modular, standards-driven architecture fostered intense involvement by firms, regulators, and standards bodies, while its technical core remained sufficiently stable (Sarac et al., 2010) to allow examination of changes in performance expectations, concrete outcomes, and evolution patterns without the complication of radical design shifts. These features make RFID a useful setting for examining how the temporal framing of performance expectations and concrete outcomes relates to technology evolution.

RFID is an identification and data capture technology involving three components: tags comprising chips that store and transmit data to readers via radio waves, readers that collect data from tags and relay it to servers for analysis and processing, and middleware systems that bridge RFID tags and readers on one side and enterprise IT applications on the other (Sarac et al., 2010). While the most common RFID applications involve tracking items along supply chains, current applications range from authenticating pharmaceuticals and other high-end products to facilitating payments, and from tracking baggage in airports to monitoring medical supplies in hospitals (Jung and Lee, 2015). The key documented benefits of RFID applications include improved efficiency through cost reduction, greater accuracy, and better customer service. The main challenges associated with RFID adoption involve high costs and risks associated with acquiring, developing, and integrating RFID systems into existing technical and organisational infrastructure, including ethical concerns such as loss of privacy (Bunduchi et al., 2011; Reyes et al., 2016).

While RFID was initially developed during WW2 to identify friendly aircraft, it attracted commercial interest during the 1970s and 80s, when several innovation patents were registered by US and European companies (Jung and Lee, 2015). The first RFID business applications emerged in the agriculture and transportation sectors during the 1980s, including electronic road toll collection, railcars, and animal tracking, followed in the 1990s by applications such as keyless entry systems for buildings and cars, and reusable metro and bus passes (Dew, 2006). These lead user sectors were followed in the early 2000s by retailers and automotive companies, which were instrumental in driving widespread adoption through RFID mandates (e.g., Walmart in 2003) and the founding of dedicated RFID consortia such as Auto-ID centre at MIT and EPCGlobal, which drove technology standardisation. RFID mandates and standardisation facilitated the scaling of technology adoption across the retail and related sectors (Bunduchi et al., 2011; Dew, 2006). During the rest of the decade, gradual reductions in tag cost and increasing understanding of RFID applications and their potential benefits encouraged adoption by a wider range of sectors and applications, from healthcare, defence, homeland security, and transportation to aircraft manufacturing, consumer electronics, consumer packaged goods, and retail (Jung and Lee, 2015).

3.2. Data

To investigate RFID discourse, we rely on two data sources. First, we analyse 21 years' worth of case stories published in *The RFID Journal* to examine adopters' temporal framings of RFID performance and their expressions of concrete outcomes, namely the benefits and challenges of RFID adoption. Second, we analyse trade publications available in the ProQuest database to examine the collective discourse around RFID during the same period.

The RFID Journal is an independent online magazine launched in April 2002 to provide a resource for business professionals involved in RFID adoption decision-making across a range of application areas. The journal's mission is to "*help business people understand the technology's capabilities and limits*" (2003 mission statement). This is achieved through the publication of RFID news and case stories, and later by organising annual conferences and distributing RFID awards. These efforts make the magazine an active player in shaping RFID discourse, particularly by bringing in the views of organisational adopters. We focus here on the case stories describing how organisations were using RFID, including the benefits and challenges they faced.

From its inception in 2002 until its acquisition by Elsevier in 2024, the RFID Journal published, on average, 19.4 in-depth case stories of organisations adopting RFID each year (see Table A1 in the Online Appendix). The case stories are written by journalists, based on interviews with actors leading RFID adoption within their organisations, and follow a standardised format covering adoption drivers,

implementation scope, challenges, realised benefits, and future plans. This consistency in format and coverage, combined with reliance on extensive interviewee quotes, makes the material well-suited to longitudinal comparison of how adopters framed RFID performance over time. The magazine's active role in the public RFID arena also suggests that interviewees were well aware of the impact their narratives had on shaping their target audience's RFID knowledge.

Our dataset comprises direct, quoted statements made by adopters in the full texts of 407 case stories published between 2002 and 2022, inclusive. Our analysis focuses on expressions of concrete outcomes, namely benefits and challenges, described in the case stories, and on temporal framing in adopters' statements about RFID performance.

3.3. Expressed concrete outcomes

We manually coded adopters' statements in the 407 case stories to identify the expressed concrete outcomes following Miles and Huberman's (Miles and Huberman, 1994) recommendations. Coding began deductively, applying a set of benefit and challenge codes developed from existing RFID research (Bunduchi et al., 2011) to the data. Challenges included direct implementation costs (financial) and indirect implementation challenges, comprising organisational and human-related issues. Benefits included operational benefits, involving cost savings and improved efficiency, and strategic benefits related to competitive advantage. During coding, it became evident that our data exhibited high-level granularity with respect to the specific concrete outcomes adopters expressed. For instance, many adopters noted indirect challenges related to the broader context, such as compliance with specific regulations, strategic benefits related to adopters' ability to meet environmental objectives, and a wider range of operational benefits, from improving customer experience to streamlining inventory. To accommodate this granularity, we allowed new codes to emerge inductively. Our final list of codes included operational, strategic, and generic benefits, and direct and indirect challenges (see Table A2 in the Online Appendix). Across these top-level categories, we coded 60 subcategories for benefits and 41 for challenges. The total number of mentions of benefits and challenges was computed for each case story. To ensure comparability, the results were standardised by subtracting the average from each count and dividing by the standard deviation.

3.4. Temporal framings

To analyse the temporal positions RFID adopters used to frame RFID as they discussed its performance within their organisations, we followed Hoppmann et al. (2020), who differentiate among four temporal positions producers use to talk about a particular technology, namely in terms of its potential, prospect, present, and progress performance within organisational applications (see Table A3 in the Online Appendix for examples). Temporal framing of *potential* performance conveys adopters' beliefs about the technology's anticipated future performance without a clear time commitment, such as adopters' expectations that the technology will support a wide range of applications. Temporal framing of prospect performance, which we refer to as *current prospect* temporal framing of performance, reflects set expectations about the technology within a defined time interval into the future, for instance, the anticipated goals of current adoption, such as achieving a sustainable revenue model or testing the technology before moving to full implementation. Temporal framing of *present* performance signals adopters' beliefs about the technology's performance as observed in ongoing adoption, for instance, improved accuracy or faster inventory. Temporal framing of *progress* performance reveals adopters' expectations about the relative change in technology performance compared with the past, for instance, in achieving expected improvements vis-à-vis a point in the past.

In view of the nature of our data, we expanded the concept of prospect performance to include both current and past prospect performance. Our case stories describe adopters' current RFID projects, which often build on past RFID adoption, e.g., pilots or projects in other areas. Hence, goals related to performance at some specific time in the future (Hoppmann et al.'s prospect performance) are often described retrospectively, as goals associated with past projects that were set out and then realised (or not) at some point in the past. We refer to this as *past prospect* temporal framing of performance, which signals past expectations about future performance, such as goals associated with trial RFID adoptions that were already completed.

Thus, while concrete outcomes capture the range of concrete benefits and challenges adopters express in relation to actual adoption projects (see Table A2), the temporal positions of performance framings capture the temporality of adopters' expectations vis-à-vis RFID as expressed in their discourse, i.e., whether their discourse emphasises the past, present, or future of technology performance, whether hypothetical or set as goals (see Table A3).

To identify RFID adopters' temporal framings in their direct statements across the 407 case stories, we systematically built five dictionaries of single and multi-word terms representing the five temporal positions. This process involved four steps. Step one entailed examining the 12 verb tenses in the English language and mapping them onto the five temporal positions (see Table A4 in the Online Appendix).

In the second step, we mapped the modal verbs *can, could, may, might, must, shall, should, will,* and *would* to the temporal positions. For example, modal verbs expressing past prospect performance are *could have, might have*, and *should have*.

Step three involved analysing a random sample of 20 case stories, one from each year, to identify words and word combinations commonly used to express RFID performance. Examples include *achieve, decrease, enhance, evolve, improve,* and *increase*. Some terms that were too generic were made specific to our data, for instance, "since 20", to capture a specific temporal position, e.g., progress performance.

In the fourth step, both authors analysed each term for appropriateness and relevance. Upon agreement between the authors, each retained term was then cast into the appropriate tense(s) and/or combined with modal verbs, based on the results of the preceding steps described above.

The dictionaries are listed in Table A5 of the Online Appendix.

Using string functions in Microsoft Excel, the incidences of each dictionary term were counted across the direct adopter quotes in the 407 case stories. This resulted in a sum of incidences of dictionary terms for each of the five temporal positions in the direct quotes within each story. To account for variation in the number of dictionary terms across temporal positions, scores were standardised.

3.5. Trade-press RFID discourse

To investigate the trade-press discourse reflecting RFID's evolution, we examined coverage of RFID in the trade press by searching for documents containing the term "RFID" in ProQuest for the period 2000–2024. As our interest was in publications likely to have been widely noticed by (potential) RFID adopters, we considered only trade press, including trade journals, magazines, and newspapers, while excluding The RFID Journal. The time period corresponds to the period during which the commercial adoption of RFID took off. Although RFID was patented in 1983, its use did not become widespread until the early 2000s, when the Electronic Product Code numbering system was developed and commercialised, thereby enabling universal identifiers for tracking a vast array of physical objects and opening retailing and supply chain applications (Bunduchi et al., 2011). Indeed, searches for documents mentioning RFID prior to 2000 resulted in very few hits.

3.6. Analysis methods

To explore trends in adopters' expressions of concrete outcomes, their temporal framings of performance, and trade-press coverage of

RFID over time, kernel-weighted local polynomial analyses were computed in Stata version 19.5 (see Figs. 1, 2, and 3 in the Findings). This analysis falls under the umbrella of univariate nonparametric regression, which does not make a priori assumptions about the functional form of the expected value of the response. Local polynomial analysis involves fitting the response to a polynomial form of the input via locally weighted least squares (Chetverikov et al., 2018; Cleveland, 1979). In our case, the responses (dependent variables) are, respectively, the number of concrete benefit and challenge codes, the number of uses of a temporal framing, and the number of trade-press publications that mention RFID. The independent variable is the publication year.

To investigate relationships between expressed concrete outcomes and temporal framings (RQ1) and between temporal framings and trade-press coverage (RQ2), we used Kendall's Tau-b (τ_b), a non-parametric measure that quantifies ordinal associations between variables based on the concordance and discordance of paired observations. This method was selected for its ability to accurately detect monotonic relationships, whether linear or nonlinear, within the data (Kendall, 1970).

4. Findings

4.1. Trade-press coverage of RFID

The results of kernel-weighted local polynomial regression for RFID trade-press coverage over time are shown in Fig. 1.

RFID coverage in the trade press rose rapidly at the start of the period under study, then fell sharply, rose again, and finally levelled off. These patterns align with the Gartner Hype Cycle heuristic (Fenn and Raskino, 2008) discussed earlier. The innovation trigger occurred before 2002, when early RFID developments and industry-wide standardisation efforts sparked interest in potential applications beyond the transportation and agriculture lead-user sectors, such as supply chain tracking and retail inventory management (Bunduchi et al., 2011). Inflated expectations occurred between 2002 and 2005, when wide-ranging RFID mandates from large organisations like Walmart and the US Department of Defence positioned RFID as a critical technology, garnering widespread industry attention (Jung and Lee, 2015; Ngai et al., 2008) and generating exaggerated claims about its transformative potential (Bunduchi et al., 2011). This was followed by a trough of disillusionment from 2006 to 2012, during which RFID trade-press coverage decreased sharply. After the initial hype, mounting challenges, including high costs, technical limitations, and implementation barriers, weakened interest (Smart et al., 2010). Even the high-profile adoption of RFID at the Beijing Summer Olympics in 2008 did little to spur the slope of enlightenment, which did not begin until 2012, when large retailers, such as Walmart, reinitiated their commitments by issuing new RFID mandates. New mandates renewed interest in RFID, and trade-press coverage surged again. Attention eventually levelled off by 2018, when RFID reached the plateau of productivity as the technology became standard in many industries. Trade-press RFID coverage declined after 2022 as RFID became a well-established, standard technology, no longer deemed newsworthy. This is a common pattern in media coverage of technological development, reflecting the dynamics of collective expectations in technology discourse, where early stages are marked by rapid growth in interest, followed by a plateau or decline as a technology becomes widely adopted and integrated into routine practices (Borup et al., 2006; Fenn and Raskino, 2008; Shi and Herniman, 2023; van Lente et al., 2013).

4.2. Expression of concrete outcomes of RFID adoption

Fig. 2 shows the results of kernel-weighted local polynomial analysis for adopters' expressions of concrete benefits and challenges associated with RFID adoption over time.

Early case stories increasingly highlighted concrete challenges, such as reliability and regulatory compliance, that plagued RFID

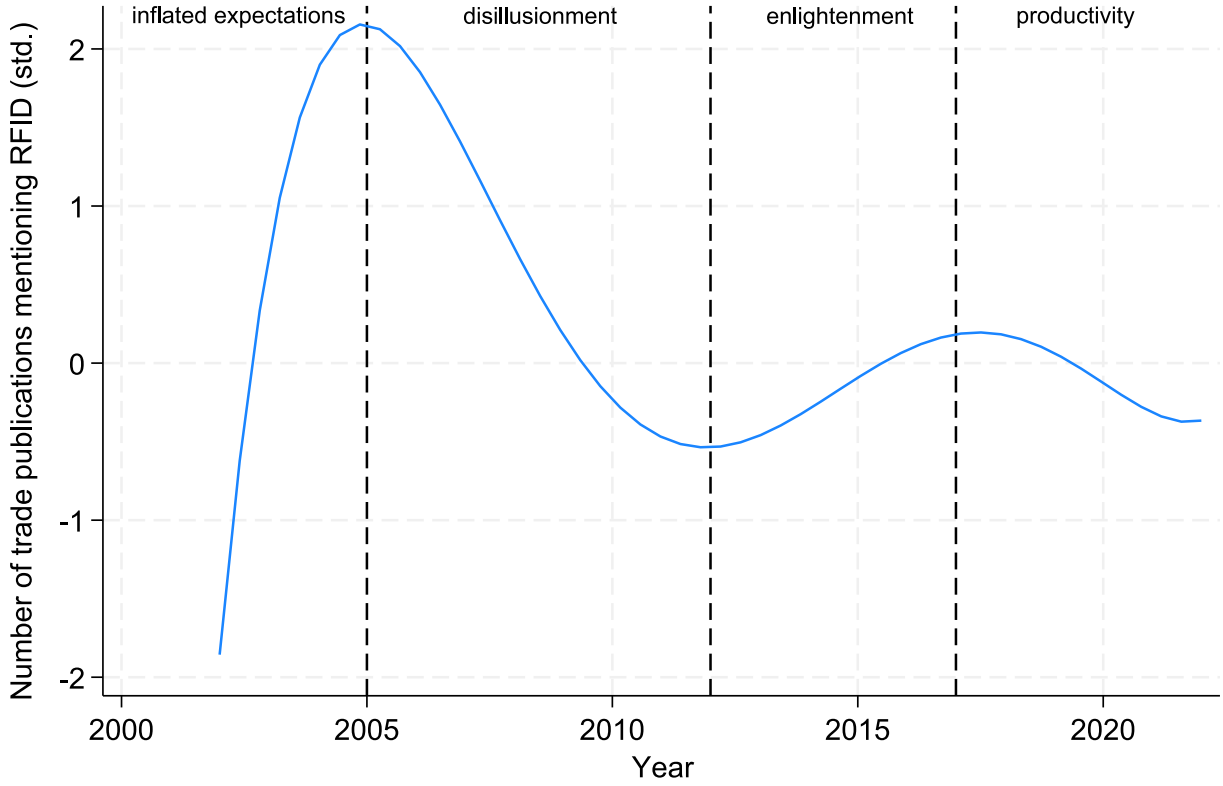

Fig. 1. Kernel-weighted local polynomial regression of trade-press coverage of RFID over time. The number of publications mentioning RFID was standardised prior to analysis so that the mean was zero and the standard deviation was one.

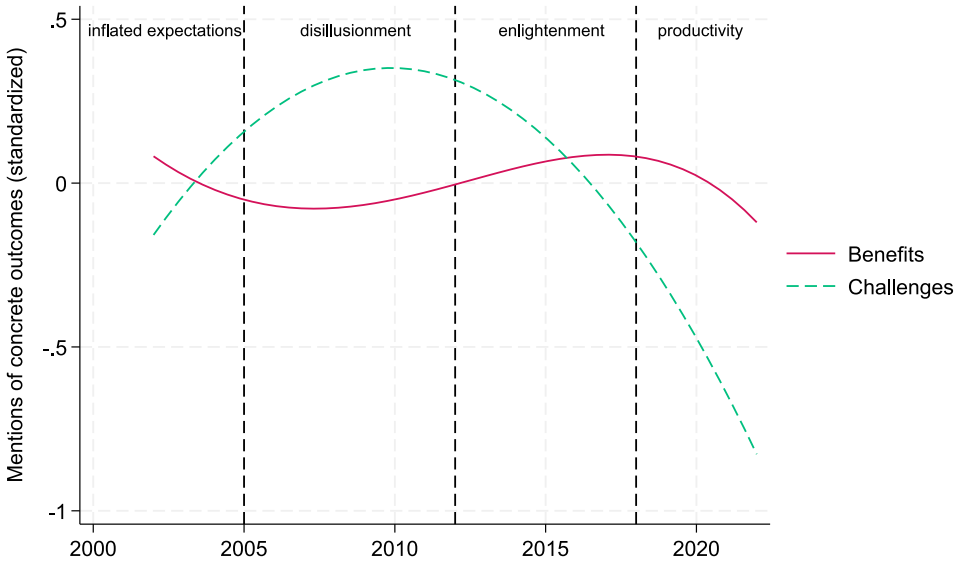

Fig. 2. Kernel-weighted local polynomial regressions of adopters' expressions of concrete outcomes in their direct quotes in case stories about RFID adoption over time. Both variables were standardised prior to analysis for comparability of patterns. Reference lines are shown corresponding to the inflection points in the Gartner Hype Cycle drawn from trade-press publication mentions of RFID (see Fig. 1).

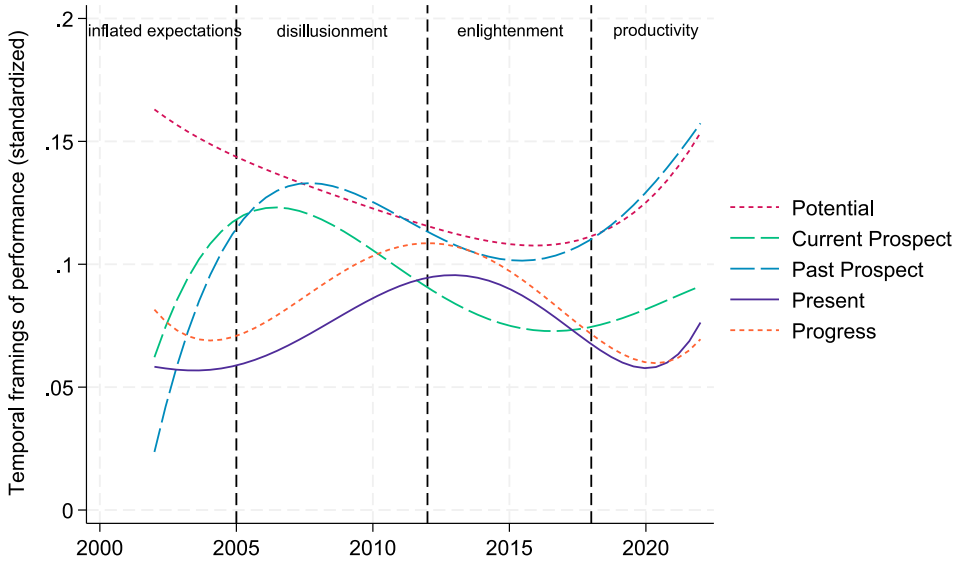

Fig. 3. Kernel-weighted local polynomial regressions of adopters' expressions of temporal framings of performance in their direct quotes in case stories about RFID adoption over time. All variables were standardised prior to analysis for comparability of patterns. Reference lines are shown corresponding to the inflection points in the Gartner Hype Cycle drawn from trade-press publication mentions of RFID (see Fig. 1).

deployments at a time when the technology was still immature and poorly understood. Expressions of challenges peaked around 2010, after which they lost urgency as RFID became established, to be replaced by a focus on the concrete benefits adopters gained from RFID. Mentions of benefits dropped during the first few years, then grew from about 2007 to about 2019, followed by another drop as RFID reached its plateau of productivity. At this point, RFID was widely accepted, which might explain why adopters' stories emphasised benefits less than before, as benefits were already well understood. These patterns, which match the overall public RFID discourse, lend credence to our coding protocol.

4.3. Temporal positions of performance in stories about RFID adoption

Kernel-weighted local polynomial regressions of adopters' temporal framings of RFID performance were computed and are shown in Fig. 3.

Fig. 3 shows the dynamics of adopters' temporal framings, which follow three patterns: a hype cycle pattern, followed by current and past-prospect temporal framings, an inverse hype cycle pattern, followed by present and progress temporal framings, and a decline and resurgence pattern, followed by potential temporal framing.

Present and progress temporal framings started out low in 2002, with present temporal framing remaining low while progress temporal framing further decreased throughout the inflated expectation stage. Present and progress temporal framings involve statements about the present performance of a technology, either in absolute terms or relative to a situation prior to adoption, or as performance changes compared with some point in time in the past. The low levels of these temporal framings during this stage are likely due to disappointments during the early days of RFID adoption, which were characterised by growing interest and an increased presence of challenges in adopters' stories. Both present and progress temporal framings picked up after 2005 when the collective, exaggerated expectations dropped, peaking towards the end

of the disillusionment stage in 2011. The 2008 Beijing Summer Olympics, the first high-profile events to showcase RFID, may have spurred adopters to increase their present and progress temporal framings. Both declined gradually as RFID entered its enlightenment stage in 2013, as emphasis shifted to concrete benefits, and adopters' temporal framing moved from expressing current performance (either as present or progress temporal framing) to the realisation of goals (prospect temporal framing, either current or past) and future plans (potential temporal framing of performance). This decline continued as RFID entered the plateau of productivity, but turned upward again in 2020.

Unlike present and progress temporal framings, potential temporal framing is forward-looking, involving statements about hypothetical performance at an undefined point in the future. Potential temporal framing peaked in 2002, then gradually declined until about the end of the enlightenment stage in 2017. As evidence of concrete benefits accumulated and challenges lost visibility rapidly during the enlightenment stage, adopters' potential temporal framings took off, reflecting a shift in focus from current performance to future plans to scale up RFID once challenges were overcome and the concrete benefits of RFID deployments were well understood.

Current and past prospect temporal framings broadly followed collective expectation patterns during the first part of the hype cycle, rising sharply in the early years and then declining once RFID reached the peak of inflated expectations, albeit with some delay. Current prospect temporal framing reflects statements made in the present about a technology's performance at a defined point in the future, and past prospect temporal framing reflects such statements made in the past. Both these temporal framings concern outlooks, current and past, respectively. As such, it makes sense that they follow the hype cycle during the early stages, which are dominated by inflated expectations. From 2014 onwards, major retailers began large-scale adoption of RFID, issuing (Indexit, Target) or re-issuing (WalMart) RFID mandates to suppliers. These actions had a widespread impact on supply chains and encouraged those who might have been hesitant to adopt RFID. This explains the uptick in current and, to a greater degree, past prospect temporal framing after 2014, as the outlook for RFID looked brighter.

4.4. Associations between variables over time

The longitudinal nature of the data enables directional analysis by examining associations between variables one year apart. Based on the displacement model (Dedehayir and Steinert, 2016; Fenn and Raskino, 2008; van Lente et al., 2013), it is reasonable to expect that adopters' expressions of concrete outcomes at one time will influence their temporal framings when describing technology performance at a later time. The reverse direction also warrants examination, as temporal framings at one time might influence the extent to which adopters mention concrete challenges and benefits at a later time. Regarding technology discourse as reflected in trade-press coverage, it is intuitive to assume that it is not only influenced by previous expressions of concrete outcomes and temporal framings, but it also influences both sets of variables in the future.

Trade-press coverage reflects the number of trade-press pieces mentioning RFID in a particular year and is derived independently of the other two sets of variables (adopters' expressions of concrete outcomes and their temporal framings of performance), both of which are drawn from adopters' statements in the RFID Journal case stories. While this common source could raise concerns about single-respondent bias, our analysis does not test associations between variables drawn from the same case stories. Since we incorporate a one-year time lag between variables, the associations examined are between variables derived from case stories in one year and variables from other case stories in another year.

The Kendall's τ_b results are depicted in Tables 1, 2, and 3. The full numerical results, including associations and *p*-values, are shown in Tables A6-A9 in the Online Appendix. As discussed above, we considered all possible pairs of variables to account for both possible directions of influence for each pair.

To answer RQ1, we first examined the relationships between adopters' expressions of concrete outcomes and their subsequent temporal framings of technology performance (see Table 2). We find that expressed outcomes are associated with subsequent present temporal framings at statistically significant levels during the inflated expectations and enlightenment stages.

First, the presence of statistically significant associations between expressions of concrete outcomes and temporal framings during the inflated expectations stage contradicts hype-cycle research assumptions that a lack of information about concrete outcomes early during technology evolution leads actors to form expectations in the absence of concrete knowledge (Fenn and Raskino, 2008; van Lente et al., 2013). Our findings show that even when information is scarce, what is likely limited information on concrete outcomes from very early adopters is nevertheless associated with subsequent adopters' present temporal framings of technology performance. During the inflated expectations stage, expressions of concrete challenges, e.g., high tag costs, increase rapidly, while expressions of benefits, such as efficiency improvements, decrease (see Fig. 2). We find that early adopters' decreasing expressions of concrete benefits, which may reflect a realisation that expectations were hyped, are associated with an accentuated decrease in subsequent adopters' present temporal framing. This suggests that decreased

Table 1
Summary of results of non-parametric rank correlations (τ_b) between adopters' temporal framings and trade-press coverage in one year and adopters' expressions of concrete outcomes in the next year. Results are shown for each of the stages delineated in Fig. 1. Full numerical results are provided in Tables A6-A9 in the Online Appendix.

	Inflated expectations stage		Disillusionment stage		Enlightenment stage		Productivity stage	
	Benefits(t)	Challenges (t)	Benefits(t)	Challenges (t)	Benefits(t)	Challenges(t)	Benefits(t)	Challenges (t)
Trend	Decreasing	Increasing	Increasing	Increasing	Increasing	Decreasing	Decreasing	Decreasing
Potential(t-1)			↗ accentuated increase					
Current prospect (t-1)					↘ tempered increase			
Past prospect(t-1)			↗ accentuated increase		↗ accentuated increase	↗ tempered decrease	↗ tempered decrease	
Present(t-1)						↗ tempered decrease		
Progress(t-1)			↗ accentuated increase					
Trade-press(t-1)			↗ accentuated increase		↘ tempered increase	↘ accentuated decrease	↘ accentuated decrease	

Table 2
Summary of results of non-parametric rank correlations (τ_b) between adopters' expressions of concrete outcomes and trade-press coverage in one year and adopters' temporal framings in the next year. Results are shown for each of the stages delineated in Fig. 1. Full numerical results are provided in Tables A6-A9 in the Online Appendix.

	Inflated expectations stage					Disillusionment stage				
	Potential (t)	Current prospect(t)	Past prospect(t)	Present(t)	Progress(t)	Potential (t)	Current prospect(t)	Past prospect (t)	Present(t)	Progress (t)
Trend	Decreasing	Increasing	Increasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Increasing	Increasing
Benefits(t-1)				↘ accentuated decrease						
Challenges(t-1)				↗ tempered decrease						
Trade-press (t-1)				↗ tempered decrease						
	Enlightenment stage					Productivity stage				
	Potential (t)	Current prospect(t)	Past prospect(t)	Present(t)	Progress(t)	Potential (t)	Current prospect(t)	Past prospect (t)	Present(t)	Progress (t)
Trend	Decreasing	Increasing	Increasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Increasing	Increasing
Benefits(t-1)										
Challenges(t-1)				↘ accentuated decrease						
Trade-press (t-1)				↘ accentuated decrease						

Table 3
Summary of results of non-parametric rank correlations (τ_b) between actors' expressions of concrete outcomes and their temporal framings in one year and trade-press coverage in the next year. Results are shown for each of the stages delineated in Fig. 1. Full numerical results are provided in Tables A6-A9 in the Online Appendix.

	Inflated expectations stage	Disillusionment stage	Enlightenment stage	Productivity stage
	Trade-press (t)	Trade-press(t)	Trade-press(t)	Trade-press (t)
Trend	Increasing	Decreasing	Increasing	Decreasing
Benefits(t-1)	↘ tempered increase			↗ tempered decrease
Challenges (t-1)	↗ accentuated increase	↘ accentuated decrease	↗ accentuated increase	↘ accentuated decrease
Potential (t-1)		↘ accentuated decrease		↘ accentuated decrease
Current prospect (t-1)		↘ accentuated decrease	↗ accentuated increase	
Past prospect (t-1)	↗ accentuated increase	↘ accentuated decrease	↘ tempered increase	↘ accentuated decrease
Present(t-1)	↗ accentuated increase	↘ accentuated decrease		↗ tempered decrease
Progress(t-1)		↘ accentuated decrease	↗ accentuated increase	

realised benefits lead to reduced subsequent expectations. Conversely, early adopters' increasing expressions of concrete challenges are associated with a tempered decrease in subsequent adopters' present temporal framing. This suggests that during the inflated expectations stage, when uncertainty is high and information on concrete outcomes is scarce, adopters' expressions of challenges are not necessarily seen as insurmountable barriers to technology adoption. Instead, information about challenges is seen as evidence that early adopters are engaging with and learning about emerging technologies, and, in doing so, are experiencing more challenges and learning how to solve them (Baldwin and Lin, 2002). This awareness of concrete challenges associated with technology implementation, combined with a better understanding of realised benefits, allows early adopters to adjust their expectations of technology performance in current adoption projects, as expressed in their present temporal framings.

Second, we find that previous expressions of concrete challenges are associated with a more pronounced decline in subsequent present temporal framing during the enlightenment stage. This suggests that as a technology exits the early stages of the hype cycle and becomes better understood, expressed challenges, even when their mention is declining steeply (see Fig. 2), infuse a dose of realism into adopters' assessments of current performance (present temporal framings). Notably, previous expressions of benefits are not associated with temporal framings at this stage, suggesting that as the technology matures and knowledge of concrete outcomes accumulates, adopters respond to expressions of concrete challenges, but not benefits, when adjusting their assessment of current performance. Furthermore, we find that expressed concrete outcomes are not associated with temporal framings during the productivity stage. This contradicts existing research (Shi and Herniman, 2023), which suggests that in the later stages of the hype cycle, discourse dynamics are driven by expectations grounded in logic underpinned by evidence of concrete outcomes.

For completeness, we also examined associations between temporal framings in one year and expressions of concrete outcomes in the next year. We find several statistically significant associations across all types of temporal framings and subsequent expressions of concrete outcomes across the disillusionment, enlightenment, and productivity stages (see Table 1). Past prospect temporal framings of performance, reflecting the goals set for past projects, show the greatest number of associations. Past prospect temporal framing likely shapes subsequent expressions of concrete benefits by reinforcing their visibility (tempering their decline or accentuating their increase) across the last three stages. Furthermore, during the enlightenment stage, past prospect temporal framing is also associated with expressions of concrete challenges, resulting in a tempered decrease in expressions of challenges, which are rapidly declining during this stage. While most associations involve temporal framings that either accentuate the increase or temper the decline in expressions of concrete outcomes, the only association exhibiting a different direction is between current prospect framing in one year tempering the increase in expressions of concrete benefits in the next year during the enlightenment stage. This suggests that increased awareness of current goals set by earlier technology adopters may influence subsequent adopters, tempering their expressions of benefits.

Notably, our findings indicate that the relationship between

expressed concrete challenges and present temporal framing is reciprocal rather than unidirectional in the enlightenment stage. As adopters become aware of how earlier adopters framed their current expectations of performance, this awareness shapes how they express the concrete challenges of their ongoing projects, which in turn shapes the present temporal framing of subsequent adopters.

Taken together, these results suggest that adopters' expressions of concrete outcomes and their temporal framings of technology expectations are not independent of each other, nor do they simply replace one another in driving technology evolution, as assumed by hype cycle literature (Fenn and Raskino, 2008; Shi and Herniman, 2023; van Lente et al., 2013). Rather, expressions of concrete outcomes and temporal framings in actors' discourses are intertwined in stage-specific ways as the technology evolves.

To answer RQ2, we examined associations between adopters' temporal framings of technology performance in one year and the public technology discourse the next year, as reflected in trade-press coverage of RFID (Table 3). Our findings show that different types of temporal framing not only exhibit distinct dynamics (Hoppmann et al., 2020) but also show different associations with trade-press coverage, and that these associations vary across stages. During inflated expectations, past prospect and present temporal framings in one year are associated with an accentuated increase in trade-press attention in the next year. During disillusionment, all temporal framings are associated with an accentuated decrease in trade-press attention. During enlightenment, current prospect and progress temporal framings are associated with an accentuated increase in trade-press coverage, while past prospect temporal framing is associated with a tempered increase in trade-press attention in the next year. Finally, during productivity, potential and present framings are associated with a steeper decrease, while present temporal framing is associated with a tempered decrease in trade-press attention.

Taken together, these findings answer RQ2 by showing that the association between adopters' temporal framings and trade-press coverage is stage-specific rather than uniform. Across stages, temporal framings are most often associated with accentuated movements in the prevailing direction of trade-press attention, including rising attention during inflated expectations, declining attention during disillusionment, renewed attention during enlightenment, and declining attention during productivity. This accentuating pattern is not universal, as past prospect temporal framing during enlightenment is associated with a tempered increase in trade-press attention, while present temporal framing during productivity is associated with a tempered decrease. Furthermore, the temporal framings implicated in these associations also differ by stage, indicating that trade-press coverage is not associated with adopters' framing in general, but with particular temporal framings of technology performance. This suggests that different temporal framings matter at different stages in driving technology discourse, with no single one playing a dominant role in driving discourse dynamics, as predicted by past research on expectations dynamics (Kriechbaum et al., 2018; Kriechbaum et al., 2021). Overall, all adopters' temporal framings are selectively associated with trade-press coverage dynamics, rather than simply mirroring them or being uniformly displaced by concrete outcomes.

For completeness, we also examined associations running from adopters' expressions of concrete outcomes to subsequent trade-press coverage (Table 3), and from trade-press coverage to subsequent temporal framings and expressions of concrete outcomes (Tables 1 and 2). Expressions of concrete challenges are associated with accentuated trade-press coverage dynamics across all stages, while expressions of concrete benefits are associated with tempered coverage dynamics during the inflated expectations and productivity stages. This suggests that reported difficulties are consistently part of the broader discourse, both during the hyped stages and as the technology matures. By contrast, reported benefits are associated with trade-press coverage only when concrete performance information is scarce (at the beginning of the cycle) or well established (at the end of the cycle). The reverse associations are more selective: trade-press coverage is associated with subsequent expressions of concrete benefits during the disillusionment, enlightenment, and productivity stages, and with subsequent expressions of concrete challenges only during the enlightenment stage. This suggests that subsequent expressions of concrete benefits are consistently associated with the public discourse, except during inflated expectations. By contrast, expressions of challenges are associated with previous trade-press coverage only as the technology exits the hype stages. Finally, trade-press coverage is associated only with subsequent present temporal framing and only during the inflated expectations and enlightenment stages. This suggests that trade-press coverage is associated with subsequent adopter framings of current performance primarily when the meaning of technology performance is being reassessed, i.e., as a new technology enters the market and as information on actual implementations accumulates, leading to a shift in visibility.

Notably, our findings indicate that the relationship between present temporal framing and trade-press coverage is reciprocal during the inflated-expectation stage, thereby accentuating the hype. When information on concrete outcomes is limited, how earlier adopters frame their current expectations of performance accentuates the rise in trade-press coverage, which in turn tempers the decline in the present temporal framing of subsequent adopters.

These additional analyses suggest that associations between adopter narratives and trade-press coverage extend beyond the focal relationships examined by the research questions. The patterns in our findings reinforce our challenge to the displacement account (Fenn and Raskino, 2008; Shi and Herniman, 2023; van Lente et al., 2013) and extend prior work showing that technology framings vary over time (Bojovic, 2022; Hoppmann et al., 2020) by demonstrating that temporal framings, expressions of concrete outcomes, and trade-press coverage are recursively and stage-specifically related, reflecting ongoing mutual adjustment among adopter experiences, concrete performance realities, and industry discourse rather than a simple linear movement from hype to practical integration.

4.5. Robustness analysis

To examine the possible non-neutrality of the discourse in the RFID Journal, we used the VADER function in Python to compute the sentiment of adopters' statements in the articles. VADER (Valence Aware Dictionary and sEntiment Reasoner) is a lexicon-rule-based sentiment analysis tool that returns a compound sentiment score combining positive, neutral, and negative scores. A compound score of over 0.05 is generally considered positive. The results for our data are shown in Table 4. Adopters' sentiment started at 0.21 on a scale of −1 to 1, indicating a modestly positive sentiment during the inflated expectations stage. The sentiment of adopters' statements rose by 0.18 between the inflated expectations stage and the disillusionment stage, which is still a modestly positive sentiment. Subsequent changes were minimal.

Overall, these findings provide a basis for cautiously surmising that adopters' sentiment did not exert substantial effects on their expressions of benefits, challenges, or temporal framings, particularly after the inflated expectations stage.

Table 4
Average VADER sentiment scores of adopters' statements on a scale from −1 to 1.

	Average	Standard deviation	Change in average
1 inflated expectations	0.21	0.21	
2 disillusionment	0.39	0.38	0.18
3 enlightenment	0.38	0.30	−0.01
4 productivity	0.37	0.20	−0.01

5. Discussion

This research examines how adopters' expressions of an emerging technology's concrete outcomes relate to their temporal framings of technology performance, and how those framings are associated with technology discourse, as reflected in trade-press coverage over time. Overall, the findings indicate that these relationships are selective, stage-specific, and inconsistent with a simple displacement logic.

Referring to RQ1, we find that adopters' expressions of concrete outcomes and their temporal framings do not simply replace one another. Rather, their lagged associations vary across stages, with concrete outcomes and temporal framings becoming intertwined as the technology moves from emergence towards wider use. As for RQ2, we find that adopters' temporal framings are also associated with trade-press coverage in stage-specific ways, most often with accentuated movements in the prevailing direction of trade-press attention, and the temporal framings implicated in these associations change across stages. Taken together, the results suggest that adopter narratives, concrete adoption experiences, and technology discourse are recursively connected rather than ordered in a linear progression from expectations to outcomes.

5.1. Theoretical contributions

Our findings contribute to research on technology expectations, technology discourse, and technology framing in three ways.

First, the study qualifies the displacement account that underlies much of the expectations and hype-cycle research. Existing work generally treats expectations as most influential in the early stages of technology emergence and assumes that concrete evidence gradually takes over as applications accumulate (Fenn and Raskino, 2008; Shi and Herniman, 2023; van Lente et al., 2013). Our findings do not support such a sequential view. Instead, they show that adopters' expressions of concrete outcomes and their temporal framings are selectively associated across stages of technology emergence, with associations between concrete challenges in one year and present framings in the next, and between past prospect framings in one year and concrete benefits in the next, occurring most prominently. These findings shift the focus from the persistence of expectations after evidence accumulates to the ways in which adopters re-anchor their expectations of current technology performance through the concrete benefits and challenges they encounter, report, and interpret, and to how they adjust their expressions of ongoing concrete experiences in light of how previous adopters framed their expectations of technology performance, mostly in relation to past goals these adopters set for their projects. While we know that concrete outcomes influence technology adoption decisions (Blut et al., 2022; Reyes et al., 2016), we extend this understanding by demonstrating how concrete outcomes are also associated with the ways technology adopters frame performance over time. Our contribution is to move beyond a substitution view of technology discourse dynamics, in which evidence replaces anticipation (Borup et al., 2006; van Lente et al., 2013), towards a stage-sensitive view in which temporal framings and concrete outcomes become intertwined as the technology moves from emergence towards wider use, and adopters re-anchor their framings and adjust their concrete experiences on an ongoing basis.

Second, we advance framing research by shifting the analytical focus from producers and media-level accounts to technology adopters. Prior research has mainly examined producers' framing (Benner and Tripsas, 2012; Bojovic, 2022; Hoppmann et al., 2020) or collective expectations in media discourse (Alkemade and Suurs, 2012; Kirkels, 2016; Ruef and Markard, 2010). Our findings support conceptual accounts that treat adopters as part of the actor constellation through which technology discourse evolves (Kaplan and Tripsas, 2008; Swanson and Ramiller, 1997). More importantly, we show empirically that adopters' temporal framings are associated with subsequent trade-press coverage in stage-specific ways. Specifically, we show that adopters' framing efforts exhibit the weakest associations with discourse dynamics during the inflated expectations stage and the greatest associations during disillusionment. In contrast to technology producers, who have strong incentives to hype positive expectations to increase sales (Keisler et al., 2021) during the inflated expectations stage, we show empirically that adopters play a minor role during that stage, but are instead likely to drive the steep decline in expectations during disillusionment. Furthermore, we show that these associations not only persist as the technology exits the hype stages, but also become more complex (both tempering and accentuating) and more selective (with different types of framings mattering at different stages). Adopters are therefore not only recipients of technology expectations, nor are they merely sources of late-stage evidence once concrete outcomes accumulate. Their narratives are part of the discursive work through which technology performance is made visible, assessed, and connected to broader technology discourse.

Our adopter-centred view also contributes to research on how technology framings are constructed. Existing work explains framing in terms of cognition and prior information (Kaplan and Tripsas, 2008; Orlikowski and Gash, 1994), political activity (Kaplan, 2008), and legitimation-seeking (Bojovic, 2022; Wen, 2024). Our findings point to an additional source, namely adopters' learning from other adopters' reported benefits and challenges, specifically regarding present temporal framing. Such learning does not produce a single framing trajectory but is stage-specific. In some stages, there is no association, in others, there are associations with both challenges and benefits, or only associations with expressions of concrete challenges. Adopters internalise concrete outcomes differently at different points in a technology's evolution, and this gives their present temporal framings a changing rather than fixed relation to technology discourse.

Lastly, we introduce a new methodological approach that systematically codes and quantifies adopters' temporal framings of technology performance, using a purpose-built dictionary that can be replicated for other emerging technologies. This approach enables us to trace dynamic associations among expressions of concrete technology outcomes, trade-press coverage, and temporal framings in adopters' narratives over two decades, at a fine level of granularity.

In sum, our findings contribute a richer, adopter-centred, and temporally nuanced account of how adopters' temporal framings, their expressions of concrete outcomes, and broader technology discourse are linked in stage-specific ways, and call for a more recursive account of how expectations and outcomes remain connected as technologies evolve.

5.2. Implications for practice and policy

Our findings yield several important implications for technology adopters, technology producers, and policymakers engaged in the development, exploitation, promotion, and regulation of emerging technologies such as RFID.

For technology producers, adopters, and policymakers, the central implication is that expectations and concrete outcomes should not be viewed as belonging to distinct stages of technology evolution. Even when concrete evidence accumulates, how adopters frame their expectations of technology performance remains an important part of technology discourse, driving its evolution across time. Similarly, expressed concrete outcomes, while limited during the early stages, play an important role in shaping discourse dynamics. For technology actors making technology investment decisions, this means that paying attention to how adopters express their concrete benefits and challenges during the early stages of technology evolution, and how they frame their expectations of technology performance as the technology matures, remains important to understanding the patterns of technology evolution.

A second key implication for all technology actors is that the relationships between temporal framings and concrete outcomes are not

static. The same type of narrative may be associated with different coverage dynamics at different stages, and different temporal framings become more or less salient as the technology moves from emergence towards wider use. For any technology actor making technology investment decisions, continuous attention to the interplay among temporal framings, expressions of concrete outcomes, and trade-press coverage can therefore support more realistic expectation management, reduce overreliance on simple hype-cycle readings, and distinguish between temporary disappointment, accumulating implementation knowledge, and genuine technological maturity.

For technology adopters, our findings highlight the importance of managing expectations through framing throughout the technology's evolution. Our findings should sensitize adopters to the fact that their own concrete experiences of technology implementation are likely to be shaped not only by how other organisations report technology benefits or challenges, but also by how these organisations temporally frame technology performance. For instance, how adopters report concrete benefits is associated with past adopters' temporal framings across the stages of the hype cycle, with the exception of inflated expectations. Furthermore, these associations differ from those between previous trade-press coverage and subsequent expressions of benefits, suggesting that temporal framings in adopters' narratives influence adopters differently from trade-press coverage. For adopters evaluating an emerging technology, this implies that they should evaluate peer narratives differently from trade-press coverage and do so in a stage-sensitive manner.

The findings also have implications for adopters' communication. Because adopters' temporal framings are associated with subsequent trade-press coverage, adopters should recognise that their accounts of implementation can become part of the broader technology discourse. This does not mean that adopters can control how a technology evolves, but it does suggest that their public narratives may shape how others interpret the technology's performance and maturity. Internally, temporal framing can also help adopters manage their expectations by distinguishing what is currently observed, what has improved, what remains a goal, and what is only a more open-ended possibility.

For technology producers, whether developers, vendors, or promoters, the findings suggest that adopter narratives should be treated as more than testimonials or market signals. Adopters' expressions of challenges are especially important because they recur prominently in the associations observed in our study. For instance, early expressions of challenges, when present in adopters' narratives, are not interpreted by subsequent adopters as signs of failure, since they may also indicate active experimentation and learning. Conversely, later expressions of benefits may say less about the ability to deliver value than about the consolidation of already-understood applications. Producers should therefore not treat reported challenges simply as negative signals to be minimised. They may also indicate where implementation knowledge is accumulating, where support infrastructures are needed, and where claims about future performance may require recalibration. Similarly, producers should be cautious about relying on potential and past prospect framings when concrete implementation experience has become more widely available. At later stages, credible promotion is likely to depend less on hypothetical future or mention of past goals achievement, and more on emphasising current performance, either in relation to ongoing projects or as progress versus past performance.

For policymakers, regulators, standards bodies, and industry intermediaries, the findings highlight the value of monitoring adopter narratives as part of broader technology assessment. Trade-press coverage alone may indicate a technology's visibility, but it does not reveal how adopters view its performance. Conversely, adopter narratives offer insights into concrete benefits, implementation challenges, and the temporal framing of performance, but they do not, on their own, capture broader attention dynamics. Considering these sources together can support more balanced assessments of emerging technologies, particularly when public attention is high but concrete evidence remains uneven, or when attention is declining even though implementation learning continues.

5.3. Limitations and directions for future research

Since the interviews and case stories were conducted and written by journalists, we do not have information on adopters' willingness to share their stories with the RFID Journal. As such, we cannot assume the extent to which their temporal framings in these stories are intended to reveal how they construct their own meaning of RFID performance, or their intention to influence others' interpretations. To capture this nuance, future work could triangulate adopters' statements in published case stories with primary adopter communications (e.g., interviews, press releases, earnings calls, internal documents) to better isolate adopter-held frames. In-depth interviews with adopters would also be helpful, although these would need to be conducted in real time during technology evolution to reflect their current framings. Future research could also compare adopters' direct statements with the surrounding journalistic text to examine how adopter framings are selected, amplified, or translated in published technology narratives.

Another limitation of our research is that, although we focus on trade-press coverage, we do not consider broader public discourse in the mass media. Future research, especially for controversial technologies that feature strongly in public discourse, such as AI or genetically modified crops, could also examine technology mentions in wire feeds, on social media, and in other public outlets, thereby capturing how the general public frames the technology. This would enable a comparison of trade-focused discourse with wider public discourse and an assessment of whether the stage-specific associations observed here in adopters' narratives are specific to industry-facing technology discourse or also appear in broader public arenas.

Finally, because of our focus on the adopter perspective, the patterns we observe in temporal framings and expressions of concrete outcomes apply only to technology adopters. They reflect adopters' awareness of concrete outcomes, shaped by their experiences of technology adoption and their interests in deciding whether and how to invest in a technology. Although our focus on technology adopters is warranted by the limited attention adopters have received in framing research, future research could examine adopters and producers in tandem. Such work could clarify whether producers' and adopters' temporal framings follow similar trajectories, whether one tends to lag the other, or whether the relationships among temporal framings, concrete outcomes, and technology discourse differ more fundamentally across actor groups.

Declaration of AI-assisted technologies in the writing process

During the preparation of this work, the authors used Grammarly to check for style and grammar mistakes. After using this tool, the authors reviewed and edited the content and take full responsibility for the content of the article.

CRediT authorship contribution statement

Raluca Bunduchi: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marina Candi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.respol.2026.105622.

Data availability

The authors do not have permission to share data.

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