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The value and structuring role of web APIs in digital innovation ecosystems: The case of the online travel ecosystem

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ABSTRACT

Interfaces play a key role in facilitating the integration of external sources of innovation and structuring ecosystems. They have been conceptualized as design rules that ensure the interoperability of independently produced modules, with important strategic value for lead firms to attract and control access to complementary assets in platform ecosystems. While meaningful, these theorizations do not fully capture the value and structuring role of web APIs in digital innovation ecosystems. We show this with an empirical study of the online travel ecosystem in the 26 years (1995–2021) after the first Online Travel Agencies (OTAs) were launched. Our findings reveal that web APIs foster a dynamic digital innovation ecosystem with a distributed networked structure in which multiple actors design and use them. We provide evidence of an ecosystem where decentralized interfaces enable decentralized governance and where interfaces establish not only cooperative relationships, but also competitive ones. Instead of locking in complementors, web APIs enable the integration of capabilities from multiple organizations for the co-production of services and products, by interfacing their information systems. Web APIs are important sources of value creation and capture, increasingly being used to offer or sell services, constituting important sources of revenue.

1. Introduction

Since the late twentieth century, the vertically integrated innovation model that Chandler (1977) described has undergone a process of unmaking (Langlois, 2003), and distributed forms of innovation are blurring organizational boundaries (Chesbrough, 2003; von Hippel, 2006; von Krogh, 2012). Accordingly, managers and researchers increasingly recognize that a firm's environment is a source not only of competition but also of external value (Iansiti and Levien, 2004), and is the site where trajectories of innovation unfold. Drawing on an ecological metaphor, the term ecosystem conveys that businesses dynamically develop symbiotic relations with other actors and coevolve their capabilities and roles (Moore, 1993). Ecosystem actors are self-interested but interdependent, and jointly create value (Bogers et al., 2019). Given that they are not hierarchically managed, understanding the mechanisms that sustain these relationships and coordinate action become paramount (Baldwin, 2019; Kapoor, 2018). In this regard, interfaces play an important role in enabling and coordinating distributed innovation by facilitating the integration of external sources of innovation (Baldwin and Clark, 2000; Cabigiosu et al., 2013; Gawer, 2020, 2009; Ghazawneh and Henfridsson, 2013; Jacobides et al., 2018).

Platform literature has informed current understandings of the structuring role and value of interfaces in innovation ecosystems. Within this literature, interfaces are theorized as design rules that ensure the interoperability of independently produced modules. They hold important strategic value, as they enable platform leaders to attract, align, and control access to complementary assets, thus structuring hub and spoke relationships in ecosystems that are organized around the development of platform technology (Baldwin, 2021; Baldwin and Clark, 2000; Baldwin and Woodard, 2009; Gawer and Cusumano, 2014; Jacobides et al., 2018; West and Dedrick, 2000).

The conceptualization of ICTs and digital technologies as modular architectures (Baldwin and Clark, 2006; Yoo et al., 2012) has been influential in framing digital innovation research in the last 10 years, resulting in the dominant view that digital innovation ecosystems are platform ecosystems, typically orchestrated by a single firm (de Reuver et al., 2018; Gawer, 2014; Ghazawneh and Henfridsson, 2013; Yoo et al., 2010). While meaningful, this literature does not capture the distinctive

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economic value and structuring role of web Application Programming Interfaces (web APIs) in digital innovation ecosystems where technology is the enabler of innovation.

Application Programming Interfaces (APIs) connect software components; they have been important to the development of ICTs, and the subject of considerable study in platform literature (e.g. Baldwin and Clark, 2006; Gao and Iyer, 2006; Gawer and Cusumano, 2002; Ghazawneh and Henfridsson, 2013; Langlois and Robertson, 1992; Teece, 1986; West and Dedrick, 2000). *Web* APIs are a specific type of API (sometimes referred to just as APIs) that use the Internet and Web protocols, standards, and technologies for the interactive exchange of messages between modular software components that may be controlled by different companies. Functionally, a web API consists of two pieces of software (known as endpoints) which parse messages sent across the internet (Jacobson et al., 2012). Web APIs were first introduced by Salesforce in 2000 (API Evangelist, 2012; Tan et al., 2016). Their relevance has increased in the last decade since web APIs are "becoming the backbone of Web, cloud, mobile, and machine learning applications" (Tan et al., 2016, p. 64), such that reference to open or public APIs in the context of the digital economy mostly refers to web APIs (API Evangelist, 2012). The technological development and establishment of web APIs as standards for the interactive exchange of messages across interorganizational web systems is economically important to the digital economy (Niinioja et al., 2019). To exemplify, as early as 2016, Salesforce made $5bn annually in revenue from its web APIs; 60 % of its transactions used them, amounting to $1.3bn daily transactions (Tan et al., 2016; Vukovic et al., 2016). By 2019, ProgrammableWeb (a directory of public web APIs) listed 22,000 web APIs for use by developers, with around 220 added per month (Santos, 2019). In addition, new tools and services are being developed to support businesses in leveraging web APIs. For instance, Apigee (a web API management service) showed a 46 % increase in web API calls between 2019 and 2020, amounting to 2.21 trillion calls.

To further our understanding of the implications of web APIs in digital innovation, we conducted a qualitative longitudinal case study of the online travel ecosystem over 26 years (1995–2021). The first Online Travel Agencies (OTAs) were launched in 1995 to match offer and demand, and to facilitate online booking. Since then, the online travel ecosystem has grown substantially and coevolved with web APIs. What often appears to the user as a single travel website, today involves a network of systems from multiple firms interacting seamlessly through web APIs. We used three main sources of public archival data to understand the online travel ecosystem and the use of web APIs: ProgrammableWeb, Wayback Machine, and travel specialist publications. We also analyzed the technical characteristics of web APIs (see Appendix B). These corpora allowed us to address the following guiding research question: What is the structuring role and value of web APIs within the online travel ecosystem?

Our analysis reveals that the online travel ecosystem has coevolved with the development and adoption of web APIs. Web APIs are increasingly used by firms to interface their systems with those of other firms, constituting a complex interorganizational digital infrastructure (Tilson et al., 2010) of networked systems. Web APIs enable not only the exchange of data, but more significantly, the processing of data through the interactive exchange of messages (calls and responses) between systems, allowing firms to provide digital resources and capabilities for the co-production of services and products. Web APIs build upon open protocols and web technologies, making them relatively easy to imitate and adapt, thus leading to highly competitive, rapidly changing, and fluid digital innovation ecosystems. As a result, web APIs are important enablers of value creation and capture by configuring dynamic and networked digital innovation ecosystems with decentralized governance. We show this by researching the online travel ecosystem's formation not as a platform ecosystem, but as a loosely interconnected, interdependent network of actors that coevolve capabilities and work both cooperatively and competitively (Moore, 1993; Nambisan and Baron, 2013; Wang, 2021) to develop the new products and services that grow and configure the ecosystem.

Our research contributes to current understandings of interfaces. Firstly, it shows the distinctive economic value of web APIs in digital innovation ecosystems that do not have a platform technology as the focal value proposition, but instead leverage technology to innovate. In this context, the main value of web APIs is not locking in complementors, but the integration of capabilities to co-produce services, which involve the processing and analysis of data in real time. In addition, they can be a direct source of value capture through their monetization, as they are used to offer services, and not only to attract complementary assets. Secondly, we provide evidence of the role of web APIs in structuring a digital innovation ecosystem with decentralized governance, where interface development is also decentralized.

2. Literature review: ecosystems and interfaces

The notion of business ecosystem was introduced by Moore (1993) to convey that businesses belong to economic communities, where members coevolve capabilities and roles. The integration of external capabilities and assets available in an ecosystem has since been identified as an important source of innovation (Iansiti and Levien, 2004); growing interest in innovation ecosystems has produced a variety of definitions (Bogers et al., 2019; Kapoor, 2018). A shared tenet is that ecosystems involve the creation by various actors of value that they could not have created independently. Ecosystem members are self-interested and not hierarchically managed, yet they are interdependent in the creation of products or services (Adner, 2006; Bogers et al., 2019; Iansiti and Levien, 2004). Understanding how these interdependences are created and coordinated constitutes a key area of inquiry and has resulted in two main conceptualizations of ecosystems (Hou and Shi, 2021).

On the one hand, the coevolution, or business ecosystem perspective, conceptualizes the ecosystem as a community of actors organized around a focal firm (Iansiti and Levien, 2004; Moore, 1996, 1993; Teece, 2007). Adopting a processual view of ecosystems, this stream of research has shed light on the symbiotic relations of ecosystem members, who coevolve capabilities around innovations (Moore, 1993; Teece, 2007). Products and services in an ecosystem exist in relation to other products and services, and the interdependence of actors is such that their success becomes increasingly dependent on others' success, in a challenging interplay between competition, collaboration, and the need to allow for growth of diversity and innovation (Iansiti and Levien, 2004).

On the other hand, the structural, innovation, and platform ecosystem perspectives anchor the ecosystem around a focal value proposition or innovation (Adner, 2017; Jacobides et al., 2018), such as a technological platform (Baldwin and Woodard, 2009; Ceccagnoli et al., 2012; Gawer and Cusumano, 2002). This literature tends to adopt a static, cooperative view of ecosystems (Hou and Shi, 2021) and addresses how ecosystem members coordinate action towards a shared goal. This shared goal is mostly assumed to be defined by a "lead firm" or architect that also orchestrates the ecosystem. An ecosystem is characterized by the structural alignment of multilateral interdependences towards a focal value proposition (Adner, 2017; Jacobides et al., 2018). In this regard, interfaces have been identified as important structuring mechanisms designed by platform sponsors to align the contribution of complementors in innovation or standards-based platform ecosystems (Gawer, 2014; Baldwin, 2021).[2]

Platform and modularity literatures have informed current understandings of the structuring role and economic value of interfaces in

[2] From a product innovation or engineering design perspective, the terms innovation platform (Gawer, 2014) or standards-based platform (Baldwin, 2021) are used to differentiate them from transaction platforms, which are defined from an economic perspective as double-sided markets (Rochet and Tirole, 2003).

innovation ecosystems. Mostly adhering to the mirroring hypothesis (Colfer and Baldwin, 2016), modularity associates system architecture with the organization of its production (Baldwin and Woodard, 2009; Gawer, 2009). A modular architecture decomposes a system into modules with independent functionalities. Interface specification ensures the interoperability of modules (Baldwin and Clark, 2006; Baldwin and Woodard, 2009), which can, thus, be independently produced (Parnas, 1972). Therefore, interfaces lower coordination and transaction costs of splitting the production of components across firms (Baldwin and Clark, 2000).

A standards-based platform is a type of modular architecture with a core that remains fixed or has low variety, and variable complements that extend its functionality (Baldwin and Woodard, 2009). Making interface specifications accessible to industry partners or openly available allows a platform leader to externalize the development of complementary modules (Gawer and Cusumano, 2014), supporting the creation of platform ecosystems and fostering innovation (Gawer, 2009; Gawer and Cusumano, 2014; Langlois and Robertson, 1992). Thus, interfaces play an important strategic role for platform sponsors in attracting and orchestrating complementary innovation (Gawer and Cusumano, 2014; West and Dedrick, 2000), which adds value to the platform, making it more customizable to user's needs (Krishnan and Gupta, 2001; Langlois and Robertson, 1995).

Furthermore, interfaces are known to provide competitive advantage to platform sponsors competing to maintain leadership over the market (Bresnahan and Greenstein, 1999), as they help lock in consumers and complementors, who incur switching and specialization costs, respectively (Farrell and Saloner, 1992). While control over interface standards does not guarantee leadership (e.g. West and Dedrick, 2000; Windrum et al., 2019), and some complementors incur the costs of multihoming (Eisenmann et al., 2009), network effects tend to maintain a platform's dominance (Eisenmann et al., 2006; Parker et al., 2016; Rochet and Tirole, 2003). Therefore, research establishes that the main value of interfaces in ecosystems is in attracting and controlling complementary assets.

Platform ecosystems are mostly conceptualized as centrally orchestrated by a lead firm, which defines interfaces to align third-party contributions. Therefore, interfaces are seen as design rules that structure hub and spoke relationships (Jacobides et al., 2018). This focus on centralized governance—predominant in ecosystem literature more generally—fails to capture distributed agency and its effects in contexts where heterogeneous, dynamic actors with diverse goals engage in collective innovation processes (Bogers and West, 2012; Nambisan et al., 2017). Research has shown that innovation ecosystems can be orchestrated through adaptive (Furr and Shipilov, 2018; Hurmelinna-Laukkanen and Nätti, 2018; Reypens et al., 2021) and collective forms of governance, involving a range of actors such as consortia (Evan and Olk, 1990; Leten et al., 2013). Only recently, has research started to consider distributed, non-centralized, forms of ecosystem orchestration (Gupta et al., 2020; Olk and West, 2023). A small body of literature addresses platform ecosystems with collective governance, where multiple firms or consortia might cooperate in defining APIs and standards (Eisenmann et al., 2009; O'Mahony and Karp, 2022). Still, the locus of control is centralized. However, no research has yet considered decentralized interface design supporting decentralized orchestration of a digital innovation ecosystem. Our research addresses this gap.

The conceptualization of ICTs and digital technologies as modular architectures (Baldwin and Clark, 2006; Yoo et al., 2012) has informed digital innovation research, resulting in a dominant view that digital ecosystems are platform ecosystems (de Reuver et al., 2018; Gawer, 2014; Yoo et al., 2010). Implicit in this research is an understanding of digital innovation as product innovation, where the focal value is technology development. However, digital technologies are not only a product to be sold in the market; they are also enablers of service and product innovation. That is, they are used by organizations to improve processes or offer services (Barrett et al., 2015; Nambisan, 2013; Nambisan et al., 2019; Vargo et al., 2008). This is increasingly so, given the digital transformation of most economic sectors (Brynjolfsson and Mcafee, 2014). We provide empirical evidence that, in this context, the use of interfaces (specifically web APIs) becomes increasingly relevant in the constitution and dynamics of digital innovation ecosystems, as well as in new forms of value creation and capture. More specifically, in ecosystems that are organized around the co-production of digital services that rely on processing data in real time.

While still focused on platform ecosystems, recent research has acknowledged the involvement of APIs not only in standards-based platforms, but also in service ecosystems (Alaimo et al., 2020; Basole, 2019; Valderrama, 2020), and in transaction platforms (Baldwin, 2021; Gawer, 2020). This research has started to consider the value of interfaces in capturing data (Baldwin, 2021; Gawer, 2020) to monitor side members in transaction platforms (Gawer, 2020), make better predictions about platform users' preferences (Baldwin, 2021) and in the development of data-based services (Alaimo et al., 2020; Valderrama, 2020). However, a focused analysis of the value and structuring role of interfaces, and particularly *web APIs*, in digital innovation ecosystems that are not organized around a platform as the focal value propositions is still missing. We address this gap with our research.

3. Methods of data collection and analysis

In researching the structuring role and value of web APIs within digital innovation ecosystems, we were compelled to define the boundaries of our empirical research (Shipilov and Gawer, 2019). However, "drawing the precise boundaries of an ecosystem is an impossible and, in any case, academic exercise" (Iansiti and Levien, 2004, p. 71). To overcome this challenge, we undertook a methodological shift. Instead of assuming a single, central orchestrator or leader, we followed the connections established via web APIs over time to trace the actors of a fluid and dynamic ecosystem. In this way, we integrate structural and coevolution ecosystem perspectives (Hou and Shi, 2021) to study the role of interfaces, while accounting for the agency of actors with diverse, and sometimes competing, goals (Bogers and West, 2012; Nambisan et al., 2017).

Accordingly, we conducted a longitudinal case study of the online travel ecosystem, supported by descriptive archival data. This responds to calls to overcome the static view of ecosystems in platform literature (Hou and Shi, 2021; McIntyre et al., 2020; Valderrama, 2020). Our study of the travel ecosystem builds upon previous research on TripAdvisor, conducted by one of the authors (Alaimo et al., 2020; Valderrama, 2020). The travel sector has exploded in the last 25 years (The World Bank, 2020) with online digital travel sales estimated at $756Bn in 2019 (Statista, 2016) representing the largest category of goods sold on the internet (Yu, 2008). Furthermore, changes in the online travel ecosystem are recognized as having had a significant impact on the entire sector (Pencarelli, 2020).

The actors of our ecosystem are firms whose online travel products and services are interdependently produced with other firms, by interconnecting their systems. During our analysis period, some firms were acquired by holding companies. We still considered these as actors if they maintained separate brands and services. We excluded flight and transport booking (see Appendix A for further details). Our research primarily centered on firms within the accommodation, restaurant, and attraction sector, as these comprise a significant number of suppliers who attract potential customers from diverse global locations. For brevity and simplicity, our analysis' narrative focuses particularly on hotel room bookings. This choice is justified as hotel booking has led most of the innovations in the ecosystem. While we acknowledge the possible influence on the ecosystem evolution of other actors such as regulators, trade associations, or those involved in defining web standards, we exclude these from our analysis.

Our methodological approach allowed us to examine web APIs from multiple perspectives across the ecosystem's history with a fine-grained

analysis unattainable through methods like large sample statistical studies (Ozcan et al., 2017). Multiple corpora of archival data, detailing 26 years of online travel (1995–2021), were used to elaborate and triangulate our findings (Pettigrew, 1990). These included: i) ProgrammableWeb, the largest directory of web APIs during our study period, ii) the Wayback Machine (WM), a digital archive of Internet sites at specific points in the past, and iii) expert travel publishers' articles from Skift (SK), PhocusWire (PW), and technical specialists (OT), as well as Skift's interviews (IN). Appendix C includes a complete list of the sources, and the acronyms used to cite them throughout the text.

Our analytical steps are illustrated in Fig. 1, with a detailed explanation provided in Appendix A. We iteratively overlapped data collection and analysis to inductively develop theoretical explanations (Eisenhardt, 1989; Yin, 2009).

We sought a holistic and temporal view of the ecosystem, with a focus on salient elements (Yin, 2009) including technical ones – specifically the services, actors, capabilities and interdependencies. This analytical approach allows a dynamic view of the ecosystem and reveals the entry of new actors. We were inspired by process research and its examination of "how and why things emerge, develop, grow or terminate over time" (Langley et al., 2013, p. 1), seeking to understand the unfolding phenomena (Ozcan et al., 2017).

To avoid our case proving too abstract (Ozcan et al., 2017; Yin, 2009), we analyzed the three corpora in search of a granular understanding of the value and structuring role of web APIs including the detailed technology of web APIs (see Appendix B). Our careful reading allowed us to build a rich case study that describes the dynamics of the online travel ecosystem over 26 years, and the relevance of web APIs upon it. We developed an in-depth case history to organize the corpus descriptively (Eisenhardt, 1989). To reduce excessive detail, we built several tables to organize our analysis (Cloutier and Ravasi, 2021; Eisenhardt, 2021).

A significant output of our analysis is the dynamic network graphs and a chronology revealing the coevolution of the ecosystem and web API usages. Network graphs are useful in visualizing complex relationships and interdependencies between ecosystem actors (Baldwin and Woodard, 2009; Iyer et al., 2006; Iyer and Basole, 2016). Our graphs represent the ecosystem actors (colored and named nodes) and web APIs offered by actors (grey unnamed nodes). Edges represent either connections between actors via web APIs (referred in figures as #web APIs connections), or the web APIs that each actor offers. The size of actors' nodes depends on the number of connections and number of web APIs offered. Our network graphs include the percentage of nodes and edges that are visible in a given period, in relation to the total number of nodes and edges over the 26 years of analysis.

Both outputs enabled us to spot four periods that are closely related to the role of web APIs in fostering the emergence of new actors, and the co-production of new services by interfacing systems from several organizations (Table 2). Given the complexity and dynamics of the online travel ecosystem, our narrative necessarily limits its level of analysis to main events, services, web APIs, and actors that marked the ecosystem's reconfiguration. We provide a description of the actors, color key, and acronyms in Table 1 and a timeline of key events in Table 2.

One limitation of researching APIs is field access for collecting data. We necessarily rely on public archival data (Iyer and Basole, 2016); unlisted, private, web APIs within the ecosystem may have been hidden. The inclusion of Skift articles and published interviews sought to mitigate this risk and helped uncover some of the travel ecosystem's dynamics, particularly before the use of open APIs. Methodological innovations for researching hidden interfacing within digital innovation ecosystems would be welcomed.

4. Analysis and findings

Our analysis reveals the coevolution of the online travel ecosystem with the web APIs that helped constitute it. One of the focal value propositions of the ecosystem, since its inception, is hotel bookings. We show how web APIs have increased interdependence among diverse actors, both newcomers and incumbents, in delivering these services. Each actor captures value, whether directly or indirectly, via web APIs within the booking process. Furthermore, some new entrants enter the ecosystem by creating their own web APIs, which are adopted by

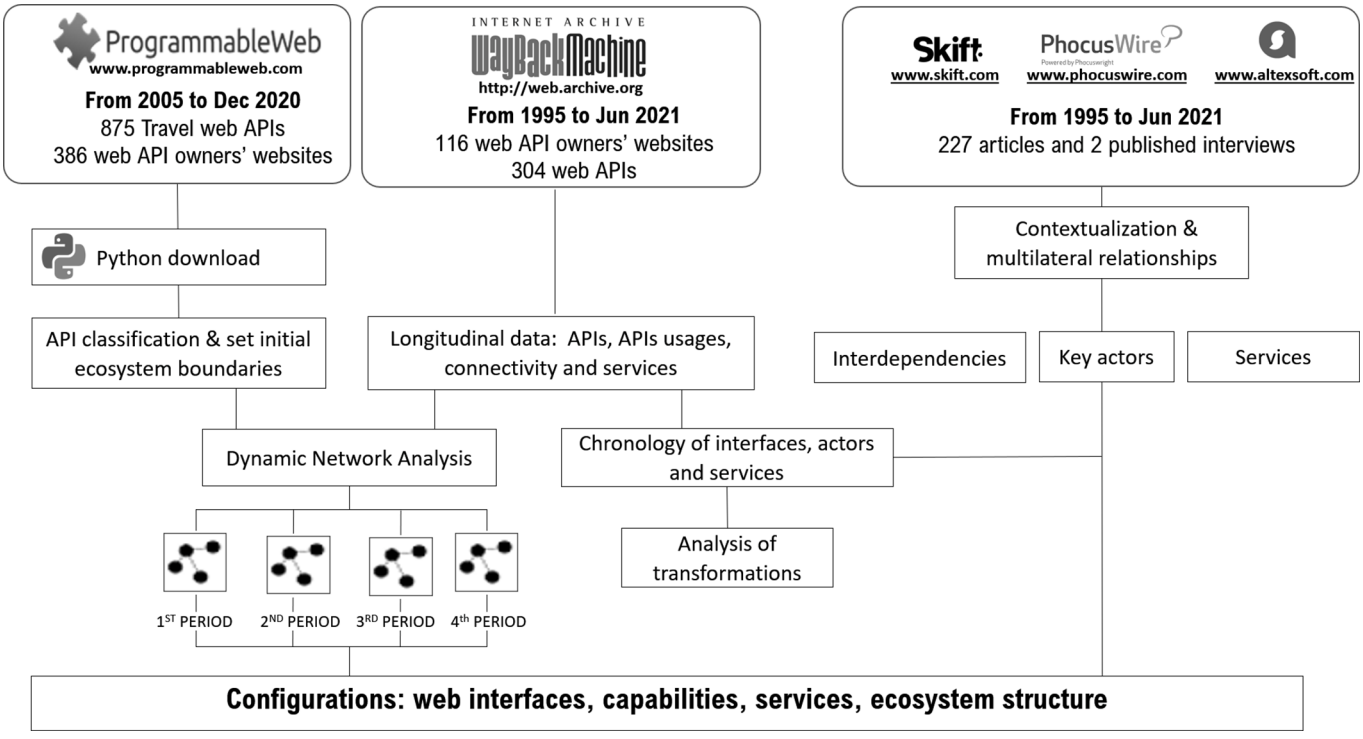

Fig. 1. Data collection and analysis.

Table 1
Actors, acronyms, and revenue models.

Category	Description	Revenue model	Examples
Distribution system (DS)	Actors involved in the distribution of travel offerings (online and offline). Among them *Global distribution systems* (GDS), Wholesalers and bed banks. Upstream connections: CM, online channel. Downstream connections: Back-office.	Licensing: payment for software package. Commission based: percentage charged over each booking. Web APIs for a fee: third parties can buy access to web APIs.	GDS: Amadeus, Sabre, Travelport
Back-office	Actors specialized in supporting hoteliers in managing their day-to-day operations through proprietary systems. Among them *Property Management Systems* (PMS) and *Revenue Management Systems* (RMS). Upstream: CM, DS Downstream: none	Licensing: payment for software package (installed on hotel computer). Subscription: software as a service (cloud based).	PMS: Pegasus RMS: EZyield
Online channel	Actors that facilitate users to see, search and book various travel-related services. Among them *Online Travel Agencies* (OTAs), *metasearchers*, travel apps, blogs. Upstream: External systems, online channels. Downstream: CM, IBE, DS, online channels.	Commission: on bookings. Subscription: Hoteliers pay to be displayed Click-based advertising: payment for redirecting users to other websites. Bidding: bid for placement.	OTAs: Expedia, Booking.com Metasearchers: SideStep, Kayak, Trivago
Channel managers (CMs)	Actors who enable hoteliers to efficiently manage the distribution of their rooms across various online channels. Upstream: External systems, online channels. Downstream: Back-office, DS.	Subscription: software as a service (SaaS).	CM: Siteminder, Derby
Internet booking engines (IBEs)	Actors who enable hoteliers to offer online bookings directly from their own websites. Downstream: Back-office.	Licensing: payment for software package (installed on hotel computer). Subscription: software as a service (SaaS)	IBEs: Ihotelier
External platforms	Actors originally external to the travel sector who provide services complementary to travel services. Among them *Affiliation platforms* (actors that manage and distribute ads in their network of affiliated websites), well-known *digital platforms*, and *payment platforms* (actors that facilitated online payment) Downstream: online channels.	Commission. Click-based advertising. Subscription.	Affiliation platforms: Awin, CJ External digital platforms: Google, Facebook, Uber Payment platforms: Paypal
APIs marketplaces	Actors who encapsulate multiple web APIs calls in one web API and offer them to third parties who can develop either new web APIs or apps and sell them in the marketplace	Subscription Web APIs for a fee	Apaleo, Mews
Social & content system	Actors involved in either the gathering of user generated content or its management to increase business visibility and reputation online. Among them review platforms (users rating and reviewing businesses), Reputation and content management (help to keep content online up to date and manage reputation online) Upstream: online channel Downstream: back-office	Commission. Click-based advertising. Subscription.	Review platform: Yelp, TripAdvisor Reputation & content management: Locu, OpenMenu, GIATA

Table 2
The online travel ecosystem timeline (1995–2021).

Period	Timeline of key events	Details of the events
First Period: The process of disintermediation of travel services (1995–1999)	1995: First Online Travel Agencies (OTAs)	Launch of Hotels.com and Booking.com (OTAs with proprietary inventory)
	1996: OTAs use GDSs' Inventory	Launch of Travelocity, founded by Sabre GDS Launch of Expedia in partnership with Worldspan GDS
	1997: First Internet Booking Engines (IBEs)	Launch of iHotelier and Passkey (IBE that enable online booking in hotels' websites)
Second period: The emergence of web APIs in a process of reintermediation through aggregation (2000–2007)	2000: First web APIs and aggregators	Launch of web APIs by Amadeus GDS Launch of SideStep first metasearch aggregating travel offerings Launch of TripAdvisor (first social travel site, aggregating travel content)
	2002: First channel managers (CMs)	Launch of DerbySoft and TravelClick (CMs synchronizing hotels' inventory to be offered online)
	2007: Seamless API integration	Launch of RateTiger and SiteMinder (CMs offering seamless integration with hotels back-office via web APIs).
Third period: Web API maturity (2008–2017)	2008: Reversal of web APIs	Launch of web API by Expedia to connect with GDSs and CMs, reversing who defined the web API
	2011: Direct booking	Launch of direct booking web API by Kayak (a metasearcher), circumventing OTAs
	2011: New metasearch and bidding web API	Google launches hotel ads and bidding web APIs, enabling access to Google's metasearch and automatic auction.
	2015: New OTAs	Launch of Google and TripAdvisor direct booking web APIs, offering the same service as OTAs
Fourth period: Monetization of web APIs (2018–2021)	2018: Web API as a service	Launch of open web API platforms by Amadeus, Booking.com, Expedia, and Sabre (incumbents), offering access to third parties wishing to harness their APIs for a fee.
	2018: Travel web API marketplace	Launch of API marketplaces by Apaleo and Mews, offering third parties a range of web APIs to develop new apps or APIs. These are offered in the marketplace and available for anyone who wants to use them in their own systems.

incumbents and sometimes repeatedly replicated. Web APIs are thus not centrally designed or promoted, rather multiple actors offer and use a range of them. This has resulted in the development of an increasingly large and tightly knit interorganizational network of information systems underlying the ecosystem. However, not all APIs were deemed sufficiently valuable for widespread adoption, usually leading to their cessation. In our corpus, we identified 52 web APIs among the 264 studied that were shut down during the period.

Through our analysis we identify four periods of the online travel ecosystem, each characterized by the emergence of new actors, by changes in actors' position within the ecosystem, and by new forms of value creation and capture through web APIs. We outline the categories of actors and their revenue models in Table 1 and provide a timeline of the major events in each period in Table 2 to contextualize the ecosystem transformation.

4.1. First period: the process of disintermediation of travel services (1995–1999)

Prior to the Web, travelers booked travel either directly (e.g. calling a hotel), or through visiting or calling a travel service provider (e.g. a high street travel agency). Customers usually searched through printed brochures to find a suitable property or flights. Human agents, working for these agencies, made bookings with providers like airlines and hotels through specialist computer terminals provided by Global Distribution Systems (GDSs), like Amadeus or Sabre, which used their proprietary communication networks, for which they paid commissions. With their long history pioneering travel reservation computerization in the 1960s, and their dominant position throughout the pre-web period (Campbell-Kelly, 2003; Copeland and McKenney, 1988), GDSs remained key players within this embryonic ecosystem, facilitating early connections and governing the early innovation trajectory. They defined standards and promoted digital systems in travel. As computers became more prevalent, hoteliers also began to keep track of bookings and managed their operations using software packages such as back-end property management systems (PMSs) and revenue management systems (RMSs) installed on their own standalone computer systems.

During the dot.com boom of the mid 1990s, actors in the travel sector began harnessing the World Wide Web to disintermediate travel services. The first Online Travel Agencies (OTAs) were created: Hotels.com was the first to launch a booking website in late 1995, joined shortly afterwards by Travelocity, Expedia, and Booking.com, companies that would eventually undermine the market role of traditional GDSs and office-based travel agencies (Castillo-Manzano and López-Valpuesta, 2010). Through the web, OTAs could potentially reach customers globally to search, view, reserve, and book. However, their booking processes still depended on manual operations such as using GDS terminals or communicating with hoteliers via telephone, email, or fax [IN1]. The first automatic connections between different actors' systems emerged with Travelocity (an OTA) and its founder Sabre (a GDS) [IN1], increasing efficiency and reducing the costs associated with the manual labor involved previously – so foretelling the way the ecosystem would develop.

Some early OTAs disintermediated the GDSs by allowing Hoteliers to manually enter their room availability and prices via the OTA's webpage. However, when a booking occurred, hotels were still informed by email, phone, or fax [IN1]. Revenue was generated through commissions for bookings, with a charge of 4 % by OTAs, which was significantly lower than that charged by GDSs [IN1].

Contributing to the process of disintermediation, Internet Booking Engines (IBEs) emerged in 1997, providing, for a license fee, software that enabled hoteliers to offer online booking within their own websites (which, until then, usually only listed rooms). Such services were of considerable benefit to hoteliers by driving direct bookings and entirely circumventing the commissions of GDSs and OTAs. These IBEs also assisted hoteliers in improving their online presence and visibility, and reduced the expenses associated with website development.

Fig. 2 shows actors in the travel industry who would eventually collaborate in co-creating services through web APIs.

4.2. Second period: the emergence of web APIs in a process of reintermediation through aggregation (2000–2007)

Our second period starts with the development of the first travel web

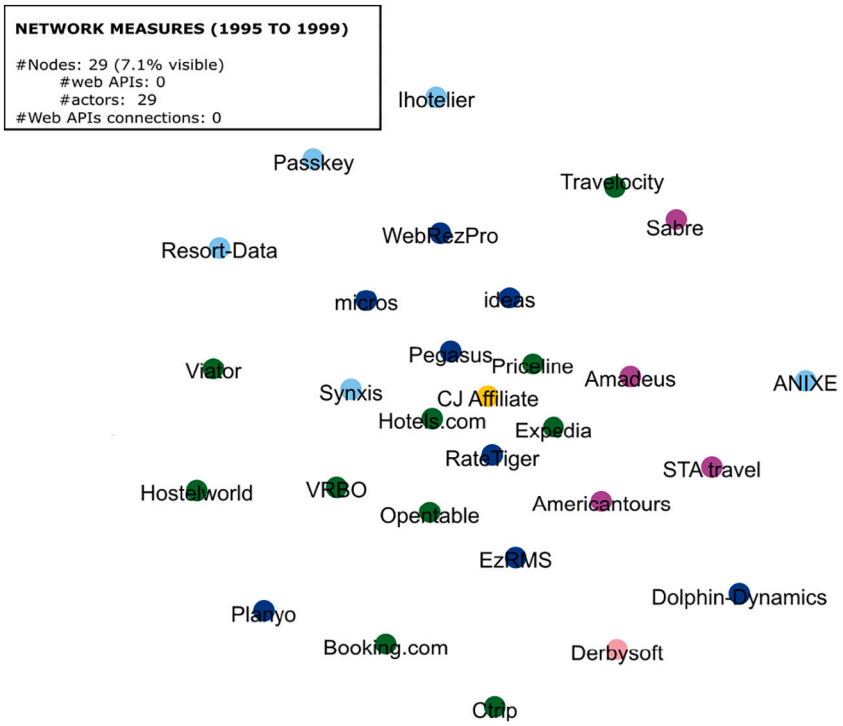

Fig. 2. Network graph (1995–1999) with color key (Table 1) used for all subsequent network graphs.

APIs by GDSs (Amadeus in 2000 and Sabre in 2003 [WM35-36, IN1, OT4]), which offered automatic room search to OTAs. These web APIs facilitated dynamic real-time exchange of messages between systems, and revolutionized the booking process, as OTAs could eliminate human involvement. Thus, OTAs could capture value by increasing booking opportunities and reducing the costs associated with the booking process. GDSs could capture value by earning commissions on bookings, and increasing the volume of bookings processed. *"For GDSs, it's a way to 're-mediate' themselves into a system where OTAs have partly displaced their model"* [PW22]. This signaled the beginning of a decentralized web API-based online ecosystem.

The increasing popularity of online travel services attracted many new OTAs and IBEs and led to a significant growth in online offerings, increasing complexity and information overload for hoteliers and customers alike. Two new entrants offered innovations to address these challenges: Channel Managers (CMs), and metasearchers. Both created their own web APIs to provide novel services that reintermediated the booking process. We discuss these two significant innovations within the ecosystem in turn.

4.2.1. *The value of channel managers' web APIs*

Hoteliers found it hard to list their room availability and manage their bookings across multiple OTAs' sites. Channel managers, such as DerbySoft and TravelClick, emerged around 2002 and created their own web APIs through which multiple OTAs and the internal hotel systems (i.e., PMSs, RMSs, and IBEs) would connect [WM15–16]. CMs primarily focused on synchronizing bookings and so ensuring that the hotel's inventory could be made available and consistent across multiple OTAs

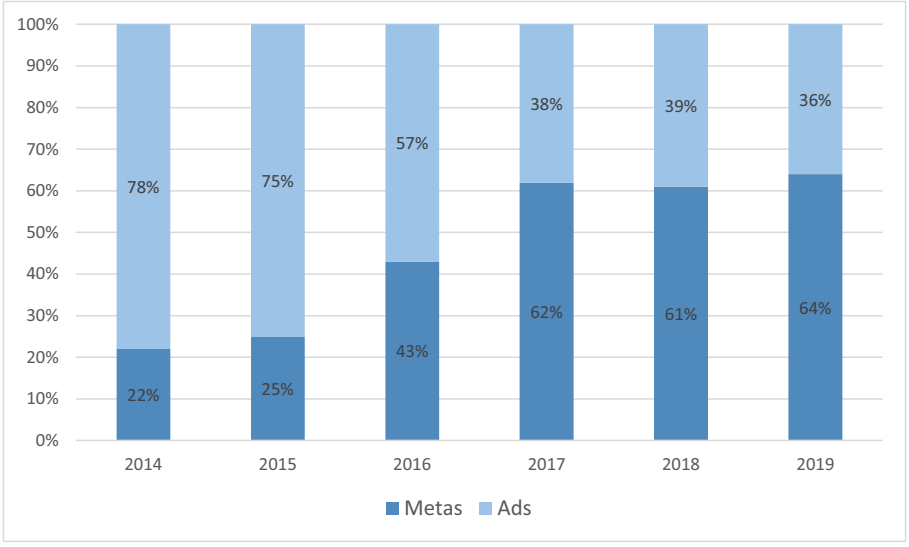

Fig. 3. Percentage of advertising on metasearchers. Figure adapted from Mirai (Delgado, 2019).

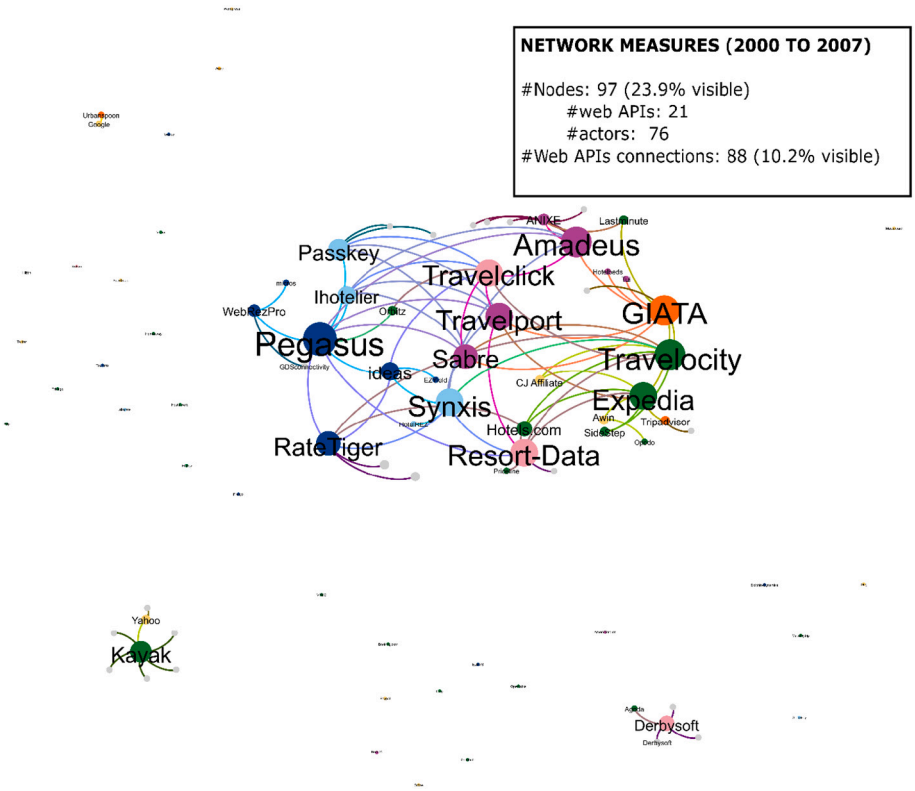

Fig. 4. Network graph (2000–2007).

[OT2–3,7–9, WM15–33]. CMs captured value by significantly enhancing efficiency, streamlining operations, and increasing booking opportunities for hoteliers (thus improving their profitability) in return for software subscription fees. OTAs were also keen on leveraging CMs' web APIs to access and list a wider range of hotel offerings and so increase their opportunity to obtain commissions on bookings.

4.2.2. *The value of metasearchers' web APIs*

Metasearchers, such as SideStep and Kayak, enabled consumers to easily search for rooms and compare prices across multiple OTAs within a single website [SK1,2,7,8, PW26]. To do this, pioneering metasearchers developed their own web-based interfaces (utilizing web scraping technology[3]) to automatically extract OTA offerings from the OTAs' website pages - without their consent. This surreptitious interface created challenges for OTAs, as it could overload their systems [IN1,2], leading to a decline in service quality for genuine customers.

However, as metasearchers proved extremely popular with customers, many OTAs recognized the value of potentially reaching new customers globally, and so reached agreements with metasearchers to co-develop private web APIs. These web APIs enabled real-time communication and proved substantially better than web scraping for both parties, ensuring offers were accurate and up to date and increasing the likelihood of bookings. These web APIs indirectly captured value by enabling metasearchers to implement a click-based advertising model. Every instance of a metasearch redirecting a user to an OTA would result in a predetermined flat-rate payment by the OTA. OTAs, through these web APIs, reach new potential customers who may make bookings, allowing OTAs to capture value by charging a commission to the hotels for each booking, increasing profitability.

By 2014, Expedia and Booking.com stated that metasearchers had become a significant means of attracting consumers, considerably boosting their revenues [PW24, SK6]. By 2019 metasearchers were the main travel channels for advertising (Fig. 3).

Fig. 4 illustrates the incipient co-creation of travel services through web APIs. It includes 20 web APIs (grey nodes) and 76 actors (colored nodes). Together this represents approximately 24 % of the actors and APIs that will be present within our total analysis period. The graph shows 68 web API connections, which account for roughly 11 % of the total connections that will eventually exist. The graph shows the growing interconnectedness via web APIs among various actors, initiated predominantly by those offering services to hotels (back-office and distribution). From the outset, the network shows the non-centralized development of web APIs, which enables the distributed co-creation of services in a decentralized ecosystem.

In summary, this period was marked by the development of the first web APIs in the online travel ecosystem. Web APIs' value lay in enhancing the efficiency of the booking process, in the aggregation and sorting of information, in the integration of capabilities, and in enabling access to potential customers. Web APIs, as the foundation of new services, captured value indirectly by facilitating commission and click-based revenue models. During this period web APIs were mainly developed by new entrants seeking opportunities to capture value through novel services targeting incumbents. Connection to web APIs were negotiated between the parties and often private. The adoption of web APIs stimulated innovation and influenced interdependencies and relationships, frequently challenging the dominant position of incumbents (GDSs and OTAs).

4.3. *Third period: web API maturity (2008–2017)*

During the third period, many web APIs became publicly available to actors within the ecosystem and so widely adopted, fostering extensive connectivity among diverse actors (refer to Figs. 6 and 7). This created

[3] Web scraping technology is the same as web API's technology in using HTTP messages to interact with webservers but receiving HTML webpage files (which the scraping software must parse) rather than machine readable XML/JSON files. Web scraping is widely used, e.g. by Google to build its website index.

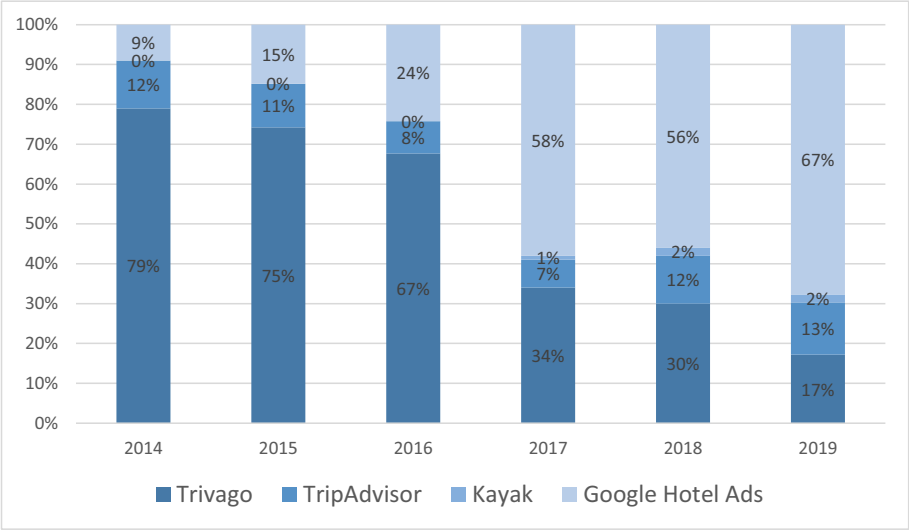

Fig. 5. Hotel spending on advertising with metasearchers. Figure adapted from Mirai (Delgado, 2019).

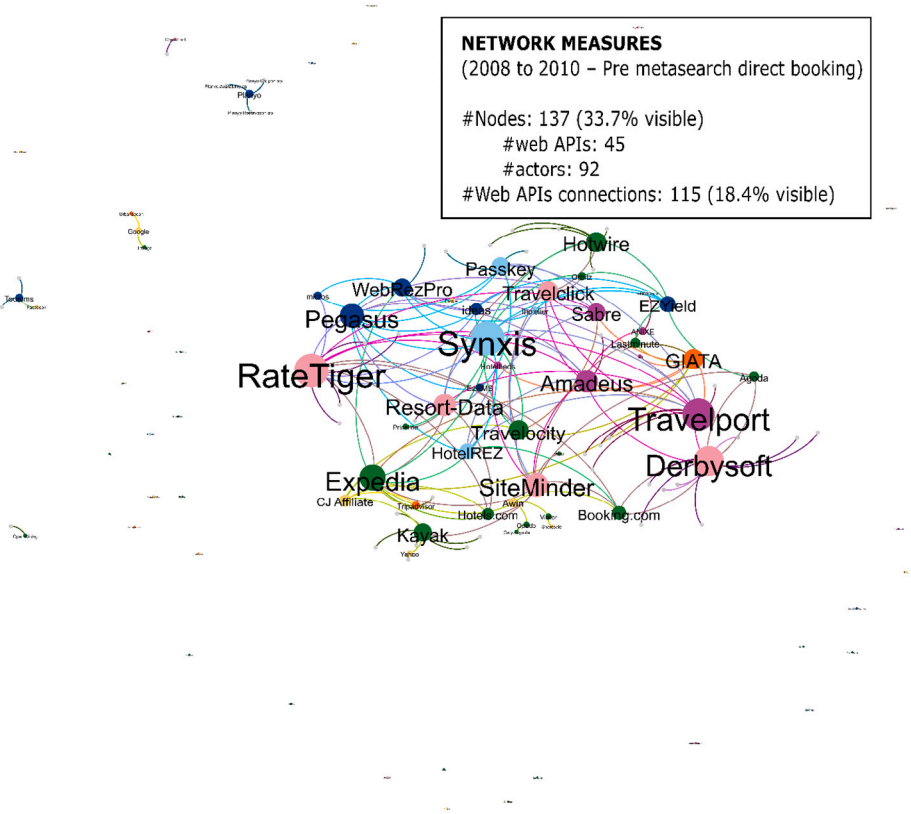

Fig. 6. Network graph from 2008 to 2010(cropped).

two distinct benefits. Firstly, it reduced the costs of individually approaching and negotiating connectivity with others. Secondly, it increased web APIs' visibility, leading to higher adoption rates. However, it also became evident that public web APIs are relatively easy to imitate. In addition, the resources required to connect to a web API are sufficiently low to justify connection to multiple partners' web APIs (see Appendix B for further details). These two features of public web APIs, coupled with the distinct value contributed by each type of actor, prevented any single actor from dominating the ecosystem. This, in turn, deepened the synergistic interdependency between actors within the ecosystem, and drove both cooperation and competition among the interconnected actors.

This period saw a cognitive shift in the business models surrounding web APIs. Whereas previously web APIs had acted as tools for real-time connectivity and supported the emergence of new entrants (often with private negotiated connections), during this period web APIs assumed a central role in driving value creation and capture through the development of new services and revenue models that collectively shaped the dynamic and structure of the whole ecosystem – something we now examine in detail.

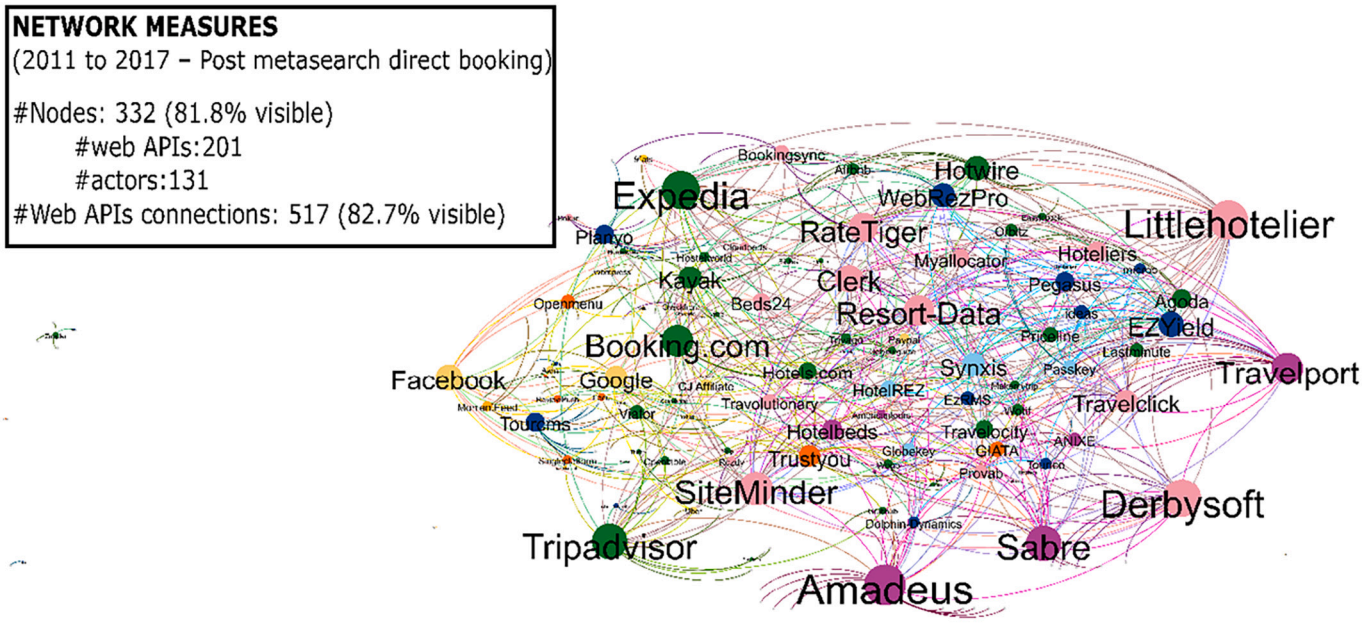

Fig. 7. Network graph 2011–2017(cropped).

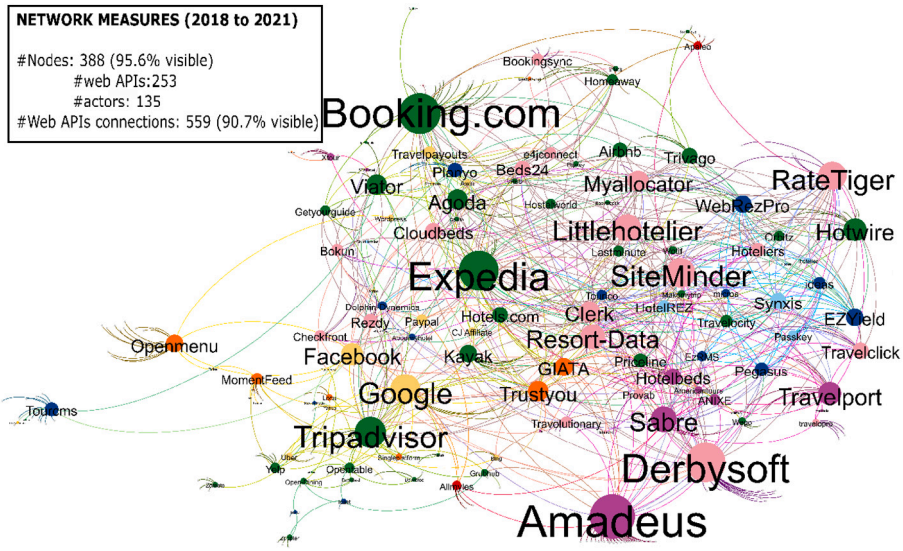

Fig. 8. Network Graph 2018–2021.

Major OTAs like Expedia and Booking.com made significant strides by developing their own web APIs, which were publicly offered to travel suppliers and subsequently brought about a substantial change in the industry landscape (WM 40, 45).

First, major OTAs managed to reverse how connectivity was established. Rather than GDSs, CMs or PMs dictating the web API to their multiple OTA partners, such actors became obliged to conform to the specific web API guidelines set by major OTAs. This change placed the onus on these actors to adapt and align with the OTAs' web APIs.

Second, the new web APIs allowed major OTAs to commercialize their capabilities. For instance, small or niche OTAs and business travel actors used these major OTAs' web APIs to improve their own services by including reviews, rankings and pictures, by adding more hotels to their offerings, or by offering travel packages. This allowed such players to expand their market reach and improve their offering while increasing the reach of major OTAs.

Third, major OTAs' new web APIs enabled them to reach more potential customers through developing affiliation programs (in collaboration with affiliate platforms like CJ and Awin) which allowed various actors, including travel-related websites and blogs, to directly advertise the OTAs' bookings. In return, such affiliates received a fixed price for each user redirected to book.

In this highly competitive landscape, as metasearchers' prominence increased they sought to compete directly with OTAs. They did this by developing additional web APIs that allowed hoteliers to promote rooms on metasearchers' sites directly from their CM or PMs. They paid a flat rate each time the metasearch redirected a customer to the hotel's own webpage. This bypassed metasearchers reliance on OTAs for obtaining price and availability information [WM41, 50], and expanded metasearchers' customer base and revenue sources. For hoteliers it avoided

Table 3
Summary of analysis.

	Innovation/new services enabled by web APIs	Value of web APIs	Main actors within the ecosystem
First period – Prior to web APIs (1996–1999)	• **Online booking** without web APIs involved	• N/A	• OTAs (new) • GDSs (incumbent)
Second period – Early web APIs (2000–2007)	• **Automated real-time price and booking** reliant on web APIs to interface several systems in order to offer real-time price and booking	• Incumbent: GDSs first web APIs offer more efficient services to OTAs, increasing the capability of processing bookings. • New entrants: metasearchers and channel managers develop web interfaces and become new intermediaries by **aggregating and sorting information** from multiple systems. • OTAs connect with metasearchers and channel managers via their web APIs to **indirectly access potential customers** (consumers and hotels). The **value and revenue is shared** by the actors who co-produce a service by **integrating capabilities** through web APIs. • Web APIs **capture value indirectly** by enabling services monetized by click-based and commission models.	• OTAs (incumbent) • GDSs (incumbent) • Metasearchers (new) • Channel managers (new)
Third period – Web APIs maturity (2008–2017)	• **Multiple capability integrations:** Development of new features based on the use of several available web APIs that bring together a number of third-party services. • Analytic services based on web API messages emerge, e.g. dynamic pricing and bidding optimization.	• Big new players (e.g., Google) and incumbents imitated existent web APIs to expand their customer-base. They easily attract many web API users by offering the capability to **attract potential consumers**. • Web APIs enhanced new forms **of value capture indirectly** by enabling analytics services (optimizing pricing and bidding) to **optimize the offering.** These services also utilize **the volume of web APIs calls** to understand the current landscape and to feed ML algorithms that **predict** prices.	• OTAs (incumbent) • GDSs (incumbent) • Metasearchers (change by offering same service than OTA) • Channel managers (adding new services) • External platforms (e.g. Google) (new)
Fourth period – Web APIs monetization (2018–2021)	• **Web API platforms** give access to multiple web APIs for innovating externally. • **Web API marketplaces** grant anyone access to the ecosystem (previously accessible only for travel players), to innovate with marketplace web APIs and to sell these innovations back into marketplaces that ran on other third-party systems.	• New players, often start-ups, can easily create competing services or products by **buying and combining web APIs** from web API platforms or marketplaces. • Value is **captured directly** by monetizing web APIs (by fee per call or by subscription).	• OTAs (some changing by building open web API platforms) • GDSs (some changing by building open web API platforms) • Metasearchers (incumbent) • Channel managers (incumbent) • External platforms (e.g., Google) (incumbent) • Web APIs marketplaces (new) • Third parties harnessing web API marketplaces and platforms (e.g. start-ups) (new)

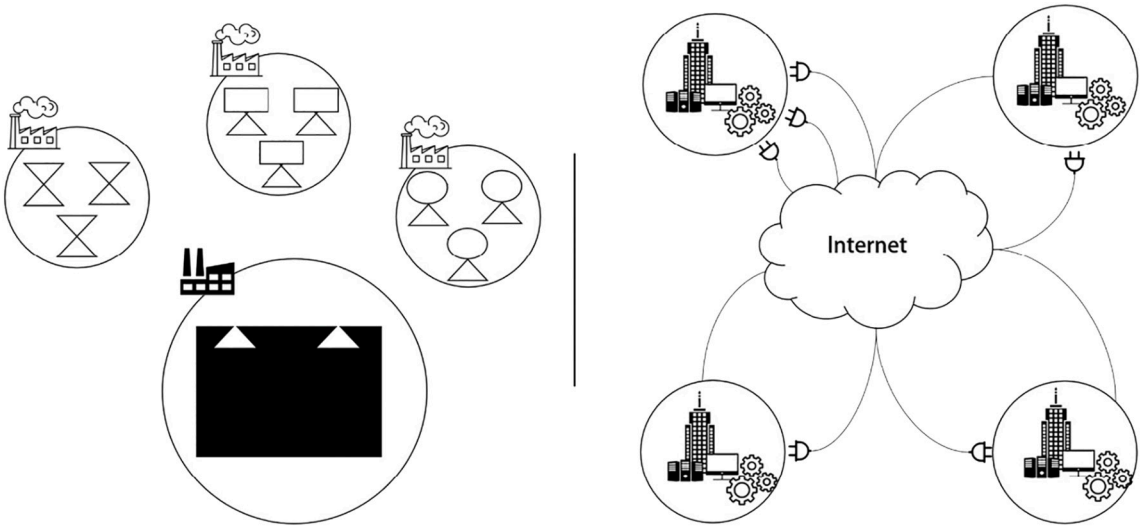

Fig. 9. Left figure: Interfaces have been conceptualized as design rules that enable governance of a platform ecosystem at a distance by a central architect. Interface specifications ensure the interoperability of independently produced modules, adding value to the platform technology, and locking in complementors and consumers. Right figure: We show web APIs are used by firms to interface their information systems, constituting a modular networked technological system. This technology is not an end product but used by actors in a digital innovation ecosystem to exchange information and integrate capabilities for the co-production of services and products. This is made possible by web APIs, which enable an interactive exchange of messages and processing of data in real time.

the commissions of OTAs that had risen from approximately 4 % in the mid-90s to around 30 % during this period [IN1, WM40–46].

As metasearcher advertising grew, a number of them (e.g. Google, Kayak, and TripAdvisor) recognized the opportunity to capture yet more value. They implemented a strategy that compelled hoteliers and OTAs to compete against each other in a real-time algorithmic auction for the placement of their rooms on the metasearcher's website [WM33].

As such bidding gained prominence, RMSs recognized the possibility to add value to hoteliers by optimizing their bidding strategies [WM15–17,30]. RMSs thus developed a new service that predicted the optimal amount to bid for metasearch placement by analyzing real-time web API messages concerning bids. Hoteliers who subscribed to this service could enhance their visibility on metasearchers' websites, and ultimately drive more successful direct bookings.

In addition, RMSs developed a dynamic pricing service which analyzed real-time web APIs transactions and user behavior to predict the optimal pricing for hotel rooms per request [WM15–17,30]. This allowed hoteliers to stay competitive in a rapidly changing competitive market. Web APIs had thus become a source of value creation in themselves since they enabled real-time analytics of the messages sent through them to provide a new service.

The next strategic move taken by metasearchers was to replicate OTAs' web APIs, to enable direct booking on their websites (for a commission). As a result, the cooperative relationship established via web APIs between these two actors became one of coopetition [SK2,9, WM41] (Ranganathan et al., 2018), given that metasearchers' websites still listed OTAs' offerings, but also their own. Actors were keen to connect directly with metasearchers to either reach more potential customers or pay less commission per booking than OTAs. By offering direct booking capabilities, metasearchers also diversified their revenue streams to include commissions (in addition to click-based rates).

Google and TripAdvisor made their first foray into the travel booking ecosystem by imitating the similar booking web APIs of metasearchers and OTAs [PW1–3, SK17, SK23–25, PW30, WM33]. This enabled them to leverage their huge user bases, initially through click-based advertising and later through commission-based models. The entry of Google, in particular, raised concerns among OTAs, however they were unable to impede its progress as other actors recognized the opportunity to increase their bookings by harnessing Google's hotel web APIs [SK14,15,17,23,31,30] to access Google's huge userbase. For example, Fig. 5 shows the trend for hotels' investments in advertising shifting to Google HotelAds.

The entry of both Google and TripAdvisor into the ecosystem highlights the potential for new entrants with a very large customer base to imitate web APIs and venture into online bookings. However, the success of web APIs depends on the value that they bring to actors within the ecosystem. For instance, while Google Hotels ads API proved to be successful, the Book on Google API failed to engage partners and customers, leading to its closure after a duration of approximately seven years [PW33].

This period shows the relatively low barriers to entry, and particularly, the limited lock-in effects of web APIs that proved easy to imitate. Further, once an actor has developed the capability of connecting to a web API, it requires little effort to connect with another web API offering a similar service. For example, analyzing who uses the web APIs of two metasearchers, Trivago and Google, we observe that 47 actors are connected to both [WM33, WM50]. Connecting to multiple similar actors' web APIs can add value. For example, Derbysoft, a channel manager, connects with 54 back-office systems and IBEs [WM15], so allowing it to offer more inventory to OTAs and metasearchers to its clients. As a result, the competition and dynamism in the ecosystem is high, and the structure of the ecosystem has become increasingly tightly interconnected.

The comparison between Fig. 6 (2008–2010) and Fig. 7 (2011–2017) highlights a significant boost in connectivity (from 115 to 517), resulting from (1) the development of new web APIs (from 45 to 201) from a variety of actors, including new entrants; (2) the replication of web APIs; and (3) actors connecting to multiple web APIs. This is evidenced by the increase in the number of connections, which went from representing 18 % of the total final period connections in Fig. 6, to approximately 83 % of the total in Fig. 7. The comparison also reveals an increase in the utilization of online channels' web APIs, reaching a size similar to those of the backend in the latter half of this period. During this period Google, TripAdvisor, and Facebook developed their own web APIs (e.g. for booking, pricing, advertising, and affiliation) and the number of actors using these web APIs proved larger than that of other incumbent web APIs, as indicated by the size of the nodes. For example, Pegasus, an emblematic PM, is notably smaller in scale compared to these new entrants.

Summarizing, this period was characterized by a marked increase in the adoption of web APIs which significantly shaped the ecosystem dynamics and structure. Competition was fierce and numerous web APIs were designed and replicated by both incumbents and new entrants. These web APIs gained broad adoption because, through them, actors enhanced their ability to capture value at a relatively low cost (in software development resources to connect to them). Instead of locking in, the value of web APIs is to integrate; consequently, they nurtured a competitive and dynamic decentralized ecosystem. This period was also marked by the development of new services that, instead of employing web APIs solely to enhance processes (as in the previous period), utilized them to maximize value capture (e.g. bidding). Dynamic pricing and bidding optimization services are noteworthy as they rely on the volume of web API calls. This information feeds into machine learning (ML) systems that predict prices and bids in seeking to maximize profitability.

We therefore show the coevolution of web APIs within this competitive and dynamic ecosystem, where firms must constantly innovate their services as they vie to remain relevant and have their web APIs called.

4.4. Fourth period: monetization of web APIs (2018–2021)

Our fourth period sees an expansion in the role of web APIs; in addition to capturing value indirectly (e.g. via commissions) they became direct sources of value capture through the monetization of the web API. This change allowed entrepreneurial third-party new entrants to harness others' web APIs for a pay-per-call fee - web APIs that were previously limited to actors already within the ecosystem. Web APIs were sold by both incumbents and new actors who developed platforms and marketplaces for this purpose. The web APIs being sold could also encapsulate simultaneous calls to multiple other web APIs.

Expanding their business models, incumbents such as Amadeus, Sabre, Booking.com, and Expedia developed web API platforms that provided documentation, tools and software code to assist anyone using their wide array of new web API services that were made available for a pay-per-call fee [WM35-36,40,45,47, SK4,19,26]. By 2021, for example, Amadeus was led by an “API-driven business model” (Heshmatisafa and Seppänen, 2023) and had over 1000 web API-based services, including web APIs for trip purpose prediction, sentiment analysis for hotel reviews, or COVID-19 restriction checks [OT5, WM35]. Each of these has a fee per call – for example the “Hotel Name Autocomplete” web API costs €0.0025 per call [WM35]. Such actors also significantly increased the range of services available through their web APIs by encapsulating, and so harnessing, web APIs of other actors within their own web API based services.

New entrants (e.g. start-ups) could easily leverage these web API platforms to create apps, services, or products, which could potentially be complements of other platforms (e.g. an App store, a social media platform, or an online marketplace). The owners of the web APIs, however, capture value each time their web API is called, and so benefit directly from the volume of calls rather than seeking to attract complementors.

New entrants such as Apaleo and Mews took this further, creating

web API marketplaces whereby third parties' web API-based services could be offered and charged on a per-call bases. Marketplace users could harness web APIs from the travel ecosystem and encapsulate them to develop services, which are then made available through their own web APIs. These were then offered in the marketplace to other third parties, for which they can charge fees. In return the marketplace charges commission.

For example, Mews offers nearly 900 third-party apps and web API connectors in its marketplace, while Apaleo offers 200 [WM39,52]. One of these, developed by Detco, is "Google Connector" that uses an Apaleo web API to enable hoteliers to list their rooms directly in Google Hotel Search, Google Business Profile, and Google Maps [WM39] for a monthly per room fee of 0.7€ per room (with the marketplace taking a portion of this). In another example, Mews provides channel manager services to innovators through a single web API that integrates more than 40 web APIs that connect to actors such as Booking.com, Google, TravelClick, and Sabre for a per-web API-call fee [WM52].

Innovators can thus harness the marketplace's web APIs to develop services themselves which they can in turn sell within the marketplace. For example, 15 third parties offer analytics and business intelligence services in Apaleo, and 26 third parties offer similar services in Mews [WM39,52]. Such services can involve advanced capabilities like artificial intelligence (AI) (e.g. DialogShift on Apaleo) which are sold through web APIs. Marketplaces, therefore, facilitate the entrance into the ecosystem of new players (e.g. start-ups) by easing the exploitation of a wide range of web APIs from a wide range of ecosystem actors. Furthermore, these marketplaces ease the monetization of such new players' innovations.

Fig. 8 illustrates a steady growth in number of actors integrating their systems via web APIs, reaching a total of 559 connections via web APIs at the end of this period. Actors who developed web API platforms (e.g. Booking.com, Expedia, and Amadeus) can be seen to grow significantly in size in Fig. 8 since the previous period as they increased the number of web APIs offered. This diagram, however, underrepresents actors that integrate via marketplace-based web APIs, as there is a lack of public information on both those platform users and of the web APIs these marketplaces have integrated into services. Given that some web APIs, firms, and connections via web APIs perished over time, they don't constitute 100 % in this period.

In summary, this period reveals the emergence of new actors, web API platforms, and marketplaces that provide services via web APIs for a fee. Web APIs had therefore become direct revenue generating services, bringing significant changes. Whereas in the third period, to enter the ecosystem large players (e.g., Google) offered capabilities to attract potential consumers, by this fourth period new entrants could just pay fees for access. This propelled innovation and the expansion of the ecosystem.

Table 3 below summarizes significant cumulative changes in the ecosystem associated with web APIs, across all four periods. In this table we identify the innovations and new services enabled by web APIs, the main value that web APIs offer, and changes in ecosystem's actors.

5. Discussion

Our research provides supporting evidence of the important role of interfaces in ecosystem dynamics, and in the integration of external sources of innovation (Baldwin and Woodard, 2009; Gawer, 2020; Ghazawneh and Henfridsson, 2013). However, while prior studies have emphasized the value of interfaces in attracting and controlling complementary assets in centralized ecosystems orchestrated by platform leaders (Baldwin, 2021; Jacobides et al., 2018; Gawer, 2020; West and Dedrick, 2000), our research uncovers the distinctive structuring role and economic value of web APIs within a digital innovation ecosystem that is decentralized, and not organized around a platform technology as the focal value proposition (See Fig. 9).

Our empirical study of the evolution of online travel uncovers a dynamic and competitive digital ecosystem, where web APIs are not centrally controlled, and they are not only developed by incumbents, but also by new entrants offering new services or reintermediating existing ones. Thus, we provide evidence of decentralized governance of an ecosystem through the decentralized development of interfaces.

Our findings are particularly relevant for understanding new dynamics of innovation in the digital economy, where data and analytics—particularly through artificial intelligence (AI), including ML—are becoming increasingly important. We reveal the role of web APIs in enabling the interactive exchange of messages with other systems, facilitating the co-production of services that rely on real-time data processing, and upon the integration of information, and digital capabilities, distributed in a network of interdependent systems. In this context, the competitive advantage that interfaces provide to a platform or firm does not lie so much in the capacity to lock in complementors, nor even on data *collection* per se, but upon increasing the capacity to process and analyze data in real time, gaining valuable contextual insights within value-adding services, which can be directly monetized.

5.1. The structuring role of web APIs in digital innovation ecosystems

Research has emphasized the role of interfaces in establishing hub and spoke relationships between a platform orchestrator and complementors (Jacobides et al., 2018) to align third-party contributions to a platform's value proposition. This assumes the centralized governance of ecosystems and control over interfaces in the design of a centralized architecture (i.e. a platform has a core). To our knowledge, our paper is the first to provide evidence of the decentralized and distributed development of interfaces in a decentralized ecosystem. We discuss this in further detail in what follows.

While ecosystem research tends to assume centralized orchestration, typically by a lead firm, a body of research has started to consider other forms of governance (Furr and Shipilov, 2018; Hurmelinna-Laukkanen and Nätti, 2018; Leten et al., 2013; Reypens et al., 2021), including decentralized governance (Gupta et al., 2020; Olk and West, 2023). In support of this research, we provide evidence of a digital innovation ecosystem that is not centrally orchestrated. It could appear as though, for example, each OTA was the platform leader of its own OTA platform ecosystem; however, we show that, through metasearchers and channel managers creating complex interdependencies with OTAs, it becomes difficult to argue what is the platform and the complementor when we research the ecosystem at a more macro level.

What existing research on decentralized governance has generally not considered is the role and value of interfaces within decentralized ecosystems. Admittedly, some research has accounted for collective forms of governance within the platform literature (O'Mahony and Karp, 2022), where design rules, such as interfaces, are not developed by a single firm but by consortia or communities. Still, the assumption is that of a centralized architecture, where only one or a small number of interfaces are designed and agreed upon by the collective. In contrast to this, our research shows an ecosystem without a single orchestrator, and where a wide range of interfaces are designed and controlled by a range of actors, in a highly decentralized manner. Our research thus contributes to ecosystem orchestration and governance theory.

As recognized in previous research (Gawer, 2020), our study shows how ecosystem actors held the dual role of users and designers of web APIs, attracting and offering complementarities. For example, channel managers synchronize hotel room inventory by *offering* web APIs to hotel back-office systems, and by *using* web APIs offered by metasearchers and OTAs. In addition, our empirical case shows how individual firms are simultaneously using and offering various web APIs for the same or different purposes, with an increasing number of many-to-many connections. Structurally, this results in connections that are not just bidirectional (e.g. platform-complementor) and explains the increasingly complex network structure of the ecosystem (see Fig. 8). Over time, through a dynamic push and pull of services and capabilities

offered via web APIs by a range of actors, an ad hoc network of inter-organizational systems emerged. Thus, we contribute an understanding of a digital innovation ecosystem with decentralized governance, where interface design is also decentralized, with a wide range of interfaces developed to form a modular, networked system without a (single) platform core to which complements are added. That is, interface design is non-centralized both from a governance and architectural perspectives.

While current understandings of interfaces predominantly adopt a static and cooperative view of ecosystems, inspired by a coevolution view (Bogers and West, 2012; Iansiti and Levien, 2004; Nambisan et al., 2017) we account for the existence of heterogeneous actors with different goals, developing and using interfaces within a dynamic ecosystem. We show that interfaces create synergistic interdependencies between ecosystem actors and their services, which are not necessarily the result of cooperation, but reactive adaptations to the ecosystem evolution and the actions of other actors.

Previous research has revealed that interface specification can be contested (Eaton et al., 2015). Our research goes further, showing that interfaces can structure directly competitive relationships within an ecosystem. For instance, by revealing, what we term, surreptitious interfacing through web scraping (e.g. by early metasearchers), we show how interfaces can be imposed upon another actor against their will. Jacobides et al. (2018 p. 2285) define an ecosystem as "a group of interacting firms that depend on each other's activities" –we might add to this: or exploit each other's activities.

With our research we thus address recent calls for integrating structural and coevolution perspectives of ecosystems to uncover blind spots in ecosystem research (Hou and Shi, 2021; Nambisan et al., 2019). More specifically, we contribute an understanding of the important role of interfaces in dynamically structuring ecosystems and advance an alternative view of digital innovation ecosystems. Drawing on Nambisan et al. (2019) and Wang (2021), we define them as loosely interconnected and interdependent networks of actors that coevolve capabilities and work not only cooperatively but also competitively to develop new products and services enabled by digital technologies and web APIs. Indeed, our longitudinal study reveals a dynamic ecosystem reconfiguration through the design and use of web APIs, whereby actors, and the services provided, constantly adapt in response to strategic needs and new possibilities for value creation. We turn to this in the following section.

5.2. The strategic value of web APIs

Previous studies have argued that interfaces are important mechanisms to control complementary assets, due to specialization costs of switching between platforms with different standards (Farrell and Saloner, 1992; West and Dedrick, 2000). Literature on standard wars has shown that control over interface standards does not guarantee leadership over time (e.g. West and Dedrick, 2000; Windrum et al., 2019), given that converters can be developed (Farrell and Saloner, 1992), or interfaces can be cloned or reverse engineered by competitors (Teece, 1986). We find various instances of this in our study; for instance, Google entered the travel ecosystem by replicating established actors' web APIs. However, the assumption in the literature is that the costs of replication and switching costs for complementors are relatively high, and network effects will tend to maintain a platform leader in position (Eisenmann et al., 2006; Parker et al., 2016; Rochet and Tirole, 2003).

Contributing to this literature, our longitudinal study and technical analysis of web APIs (Appendix B) suggests that web APIs do not enable control over standards. As web APIs draw upon open shared web standards, parsing them is relatively simple and understandable, and they are agnostic to the systems they interface. This makes them relatively easy to imitate and adapt. In addition, to facilitate the adoption of web APIs, firms tend to encapsulate relatively granular services through web APIs. Furthermore, web APIs of similar services appear likely to have similar architectural design patterns (Alexander et al., 1977; Henfridsson et al., 2014), as processes and required information for a given service (e.g. hotel booking) are somewhat standardized.

This has important implications for understanding the strategic value of interfaces. We show that web APIs proved ineffective tools to lock in complementors and so to establish leadership. Once an actor *uses* a web API, the cost of connecting to a different web API that offers the same or similar service is low, thus potentially increasing the power of suppliers and customers (Porter, 2008). Furthermore, successful web APIs can be replicated and offered by competing actors. While such replication involves costs, web APIs pose relatively low barriers to entry (resulting in the ecosystem's growth) and relatively high threats of substitutes, particularly as potential customers and suppliers will incur low switching and specializations costs (Porter, 2008). Consequently, within this context no profit sanctuary is totally safe from competition.

Competition takes place both between actors in the same category and across categories. For instance, as OTAs increased their margins, the metasearch Kayak imitated OTA web APIs to also act as an OTA that offered lower commissions. Replication was not the only mechanism to enter or compete within the ecosystem. Incumbents developed new web APIs offering new services or capabilities to remain competitive (e.g. Amadeus transformation into an API-driven business model (Heshmatisafa and Seppänen, 2023)). However, new web APIs were frequently developed first by new entrants in order to enter the ecosystem – something not recognized in the literature. Thus, we uncovered the entrepreneurial and the strategic value of web APIs in offering substitute services (Porter, 2008). Nevertheless, if successful, web APIs were often replicated by other entrants or incumbents. Furthermore, offering a web API is not the same as gaining adoption, and, unless perceived as valuable, web APIs will fail to attract users and so likely cease. Further research is thus needed to establish success factors of web APIs.

We inductively derived a two-dimensional framework that summarizes the strategic approach to web API development by different actors within the ecosystem. On one dimension, web APIs can be used to innovate or imitate an offering (though this can be seen within a spectrum); on the other dimension, those offering the web API might be incumbents seeking to maintain or grow market share, or new entrants to the market. That is, we observe existing actors devising new services or improving existing ones; existing actors imitating an existing service; and new entrants entering the ecosystems either with new or improved services, or by replicating services. While prior research focuses on the strategic value of interfaces for leaders and new entrants competing for control *over* the ecosystem, we show that attention also needs to be addressed to the strategic role of web APIs for businesses, big and small, competing to enter or remain competitive *within* the ecosystem.

An additional consequence of low specialization costs is that the cost of establishing connections with multiple firms is relatively low. Unlike for platform ecosystems (Eisenmann et al., 2009), our research provides evidence of large-scale multihoming in an ecosystem built around decentralized web APIs. Thus, a single firm might simultaneously use and offer various web APIs for the same or for different purposes. This enables the production of services that would otherwise be difficult to offer, such as aggregation and real-time comparison of price and availability. While we have argued that low specialization costs can increase the customer and supplier power, we also simultaneously show that multihoming generates competition among them, decreasing their power. For example, hoteliers are made to compete by OTAs, mainly through pricing, while at the same time incurring costs for commissions and back-office services needed to remain visible and attract customers.

Consequentially, large-scale multi-homing and ecosystem growth results, over time, in processes of disintermediation and reintermediation, through which new actors enter the market to address its increased complexity by offering new web APIs (e.g. metasearchers connecting to multiple OTAs, who in turn connect to multiple back-office systems), or use the existing APIs of competitors to disintermediate them (e.g. metasearchers offering OTA services).

Given the low replication, switching, and specialization costs of web APIs, so competition (and not only cooperation) within the ecosystem is high. We see firms constantly adapting, changing their roles, and adding existing services by replicating web APIs, but also offering new web APIs over time. Together, this helps explain the dynamism, growth, and decentralized governance of the ecosystem. However, *using* and *maintaining* web APIs does have a cost (e.g. software development costs, processing capacity, management costs). In this regard, multiple connections require capacity that small firms might not have. Furthermore, some of the services *offered* through web APIs require additional and costly infrastructure and technological capabilities such as AI. This helps explain the sustained competitive advantage of some OTAs, or the capacity of Google to enter the ecosystem. Nevertheless, further research is needed to establish the basis of sustained profitability by an entire category and sustained competitive advantage by individual firms in such dynamic ecosystems.

5.3. The role of web APIs in value creation and capture within the digital economy

The implicit assumption in most platform literature, that control over architecture translates into ecosystems' control, does not appear to hold in our case study. Or, at least, control over web APIs does not seem the most fruitful mechanism to lock in complementors and achieve leadership. So, what, then, is the value of web APIs?

Within the digital economy it is increasingly difficult to disentangle digital products and services from their underlying digital infrastructures (Bharadwaj et al., 2013, p. 472; Lyytinen, 2022; Orlikowski and Scott, 2008; Tilson et al., 2010). Our research shows that web APIs are used by actors within a decentralized ecosystem to interface their information systems and so, to co-produce services and products. That is, in digital innovation ecosystems where technology is not the final product but an enabler of innovation (Nambisan et al., 2017), the value of web APIs is not only as a design rule, and thus, as a governance mechanism, but also as a *technology-in-use* that enables the interaction of distributed systems. This results in new important mechanisms for the co-creation of value and for value capture.

Given the commoditization and value of data (Alaimo et al., 2020; Clough and Wu, 2022; Gregory et al., 2022, 2021), research has started to consider the value of interfaces in capturing data (Baldwin, 2021; Gawer, 2020) to monitor transaction platforms' side members (Gawer, 2020), make better predictions about platform users' preferences (Baldwin, 2021) and in the development of data-based services (Alaimo et al., 2020; Valderrama, 2020). The term “data network effects” (Gregory et al., 2021) has been introduced to highlight the reinforcing loop by which access to data feeds AI models, which improves services, attracting more users, and thus more data. From this perspective, it could be argued that the strategic value of web APIs lies in the control over data, instead of control over standards and architecture. We posit, however, that this needs to be qualified. While data underlies everything digital, we show that the value of web APIs is in enabling the dynamic and interactive exchange of messages between distributed systems in real time. Thus, the value of web APIs is not only in the transfer of data but in facilitating the *production* of meaningful data. Our study suggests that attention should be focused on the exchange of information and integration of digital capabilities through web APIs, and on the real-time production of information and prediction that web APIs enable.

More specifically, we show that web APIs enable: (1) the real time aggregation of data to gather up to date information (processing and generation of data); (2) the integration of capabilities to co-create services, by processing data from multiple data points in real time. For instance, a hotel booking relies among other things, on online channels attracting users, and connecting to CMs, who keep the inventory synchronized online. (3) Furthermore, the analysis of the traffic taking place through web APIs enables the development of insights of real-time behavior and the use of ML predictive analytics. This enables actors to produce new valuable information and insights in real time, and provides the analytical capacity to predict and take immediate action accordingly (e.g. dynamic pricing and bidding optimization).

In agreement with Gregory et al. (2021) we observe that there is a reinforcing loop in the analytical capacity of firms. In this regard, the increasing number of connections in the network via web APIs that we observe (Fig. 8), can be explained because of the real time informational value that such multiple connections enable. For instance, Google's analytics capabilities aided its entry as it can offer better services. This attracts more users/connections, further increasing their analytical capabilities. Not so much through control over data, but through the real-time insights that such multiple connections and analytical capabilities enable.

An indirect, but also important, form of value that web APIs enable is access to potential customers. For instance, OTAs ultimately benefited from metasearchers' large number of potential customers. Similarly, Google Hotels could enter and quickly gain an important position within the ecosystem as it offered a huge user base to their web API partners, in addition to their analytics and advertising capabilities.

Web APIs not only provide strategic value and improved services, but have also become important sources of value capture. Our analysis shows that the value of services offered via web APIs is captured through various revenue models over time. Web APIs facilitate revenue sharing models (Wulf and Blohm, 2020), such as commissions for bookings and click-based advertising, as they enable the identification of the partner who facilitated a service (e.g. a booking or redirection of customers to a website). In addition, the emergence of web API marketplaces and web API platforms in recent years is associated with the emergence of new business models, whereby web APIs encapsulate a service, and are offered, for a pay per call price. This confirms previous findings showing that web APIs can be a direct source of revenue through transaction based (e.g. per web API call) or subscription-based pricing strategies (Wulf and Blohm, 2020) – with major actors transforming their business models directly around web APIs (e.g. Amadeus). Such an approach is increasingly used by firms, who develop web APIs to sell services and products rather than to just attract complementors.

Our research shows an increasingly tight coupling between the value of web APIs and their monetization in the latter period. We show how the move towards pay-per-call web APIs supported experimentation by new actors (e.g. Detco) and drove business model changes for incumbents (e.g. Amadeus and Expedia). This extends understanding of digital innovation ecosystems, suggesting that researchers examine this coupling between value and pricing in supporting innovation.

In conclusion, our research contributes to interface theory by showing that web APIs constitute increasingly important sources of value creation and capture within the digital economy, despite their limited ability to lock in complementors.

5.4. Limitations and future research

Our research shows the methodological benefits of mapping the networks of actors within an ecosystem without presuming a central hub. Our macrolevel, longitudinal analysis allowed us to uncover relevant ecosystem dynamics of cooperation and competition, and decentralized control. However, this analytical choice comes with downsides, as we could not provide detailed analysis of firm-level strategic decisions, requiring further research.

Furthermore, our focus on the role of interfaces in a digital innovation ecosystem, has excluded other strategic and economic factors that affect the ecosystem. For instance, Bloomberg (2016) argues that Booking Holdings and Expedia Group "have successfully used acquisitions to gain market share and fend off competitive threats" with their financially successful positions being "largely a result of massive consolidation" in the OTA market. We note however that these holding companies have retained large numbers of separate services with their own web APIs (for example Expedia Group (n.d.) claims to have over 200 different travel websites). We see value in further research that critically assesses web APIs in relation to economic factors such as partnerships or mergers and acquisitions, and we welcome initial research in this area such as that by Gawer (2020), Hanelt et al. (2021), Liu et al. (2021), Valderrama (2020), and Yan et al. (2021). Further research on structural control and market share within digital innovation ecosystems would help to further our understanding of the strategies firms follow, and could contribute to explaining the under-studied dynamics of competition within ecosystems.

Gawer (2020) and Baldwin (2021) make the distinction between transaction platforms and innovation platforms. While they acknowledge the existence of hybrid platforms, our research suggests that further research focused on the use of web APIs might shed light on the potentially more complex interrelationship between these two. Indeed, as interfaces are monetized on a per-call basis (e.g. Amadeus' per search fee) so this distinction becomes hard to disentangle. We also note that transaction platforms (Baldwin, 2021; Gawer, 2020; Parker et al., 2016), such as Amazon or eBay, can have channel managers (e.g. CommerceHub), metasearch services (e.g. Google Shops and Shopzilla) and revenue managers (e.g. Price2Spy) connected by web APIs. Further research into the value creating and structuring role of web APIs in such ecosystems would thus be beneficial.

Our findings outline challenges for policy makers and researchers alike. Our fourth period evidences the complexity of decentralized web API-based ecosystems as they exist today (see Fig. 8). As web APIs facilitate the growth of increasingly interdependent systems, it becomes ever more difficult to isolate the capabilities and agency of firms, posing a challenge for those who regulate digital innovation ecosystems. In response, policy makers should consider the ripple effects of firms' actions and regulation at the ecosystem level, and for other ecosystem members, when they devise regulation of, for example, privacy, security, transparency, and competition. An additional challenge is that these networks tend to have global reach and overflow geographic and jurisdictional boundaries.

We also reveal how data analytics and AI are becoming deeply embedded across such decentralized web API-based ecosystems. As AI can benefit from harvesting data from multiple sources so we expect it to become increasingly ingrained. This embedding will make it hard to research and trace AI's impact within the digital economy– with policy implications for those regulating AI.

Finally, the substantial growth of digital innovation ecosystems like the one we studied is representative of a techno-economic paradigm increasingly reliant on advertising, personalization services, tracking, and the trading not only of data but also complex digital assets and capabilities, including AI, which raise questions on the societal outcomes it helps sustain, and which should be not only a policy concern but also an important component of future innovation research (Freeman, 2007; Mansell, 2021).

CRediT authorship contribution statement

Roser Pujadas: Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Erika Valderrama:** Methodology, Investigation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Will Venters:** Funding acquisition, Investigation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

No conflicts of interest to declare.

Data availability

Sources of data are detailed in the appendix and public

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Appendix A. Methodology and analysis details

Our research draws on a longitudinal case study of the online travel ecosystem (Shipilov and Gawer, 2019). The empirical setting was identified based on the premise that online relationships are extensively materialized via web interfaces (Gawer, 2020). We used three corpora of data: (i) ProgrammableWeb, the largest directory of web APIs,[4] to set the initial analytical boundary of the ecosystem (Basole, 2019; Evans and Basole, 2016). (ii) The web APIs and owner webpages were traced on the Wayback Machine, a digital archive of Internet sites at specific points in the past that is widely used in historical website analysis (Arora et al., 2016; Valderrama, 2020). These historical web pages constituted our second corpus (Appendix 3C), as they account for changes in web APIs and the interfacing of actors' through web APIs over time. (iii) We complemented these corpora with expert travel publishers' articles from Skift and PhocusWire, and Skift's interviews (Schaal, 2016, 2014)[5] with relevant travel players and technical specialists (Appendix C). These allowed us to contextualize ecosystem changes and provided a granular understanding of the role of web APIs in the

[4] ProgrammableWeb has been described as "the authority on open APIs and the most visited destination for APIs" supported by the largest community of API developers and users (MuleSoft, 2013; ProgrammableWeb, 2009). It closed in 2023 – after our analysis was complete.

[5] Skift News Editor Dennis Schaal first interviewed 17 Travel CEOs to better understand the business world of travel in the digital space (Schaal, 2014). Then, Skift published an oral history of online travel (Schaal, 2016), drawing on interviews to 28 of the founders and key players of the early days of online travel booking, and archival materials from participants and institutions involved.

ecosystem.

ProgrammableWeb registers the information of 875 web APIs in the travel category between 2005 and December 2020. This information includes the web API's description, owner, roll-out date, and (via URLs) the technical documentation detailing how the web API should be used. These web APIs and their 386 owners set the initial analytical boundary of our study. We discarded 179 web APIs which clearly did not contribute to the travel ecosystem (e.g., traffic, local transportation, weather) but also excluded flight related web APIs. Flight booking is similar to hotel booking, albeit at a much smaller scale as there are considerably fewer airlines than hotels and fewer other actors involved (Schaal, 2016). Furthermore, many web API owners offer both hotel and flight web APIs. Excluding flights thus reduced the complexity of our analysis with little impact on relevance. The remaining web APIs and their owners were traced through the Wayback machine, travel publishers, travel technical publishers and interviews, to build our dynamic network graph (see Table for more details) that facilitated the temporal analysis of the online travel ecosystem from 1995 until June 2021. Network graphs are relevant to visualize the dynamics of ecosystems (Baldwin, 2021; Iyer et al., 2006; Iyer and Basole, 2016).

Table A.1
Tasks involved in building our dynamic network graph.

Task	Activity
1	Tracing web API connections between 1995 to June 2021 (Wayback Machine). We identified 141 web API owners' websites that display to whom they interface their systems. These actors developed in total 264 web APIs. As we study the digital infrastructure underlying the online travel ecosystem, we consider as an actor each brand that travel holdings have. Each is relevant as they have their own web APIs. For example, Booking holdings has Kayak, Booking.com, Priceline, OpenTable, Agoda, etc.
2	We reconstructed the interfacing of systems by examining the Wayback Machine. We inspected the owners' webpages to find to whom they interfaced with when they began and when they stopped. This information was usually declared on their webpage. This tracing was complemented by Skift's PhocusWire, technical articles, and the interviews.
3	We classified the actors depending on their role in the ecosystem, arriving at 8 categories: *online booking channel* (OTAs, metasearchers), *back office* (Property management systems –PMS, central reservation systems—CRS, revenue management systems—RMS), *Internet booking engines*—IBEs, *Channel managers*, *Distribution systems* (GDS, wholesale and bedbanks), *Social & content platforms* (e.g. TripAdvisor, ReviewPush—reputation management system), *Travel APIs marketplace and external platforms* (e.g. PayPal, Facebook, Google). Each type of actor has a distinctive color within the network graph.
4	We used a software package (Gephi) to support our network analysis and visualization. We uploaded the nodes (actors and web APIs), including an id, label, node category, initial year and last year. We also uploaded the bidirectional connections through web APIs between two actors, including the year when the connection started and ended. The years were important to build a dynamic network graph that revealed changes over the years.
5	For the visualization, we selected the size of the node in relation to its degree, meaning the label and node's size depends on how many systems are interfaced with the actor's system via web APIs. In this way, we can observe if one node is acting as hub, and if this hub expands over the 26 years of the online travel ecosystem.
6	Gephi dynamic network measurement enable us to identify the period of time that the graph remained relatively stable and their breaking points and thus define the different periods.

The network graphs (Figs. 2, 4, 6, 7, & 8) represent the connections between actors' systems at a given point in time. Nodes represent the ecosystem's actors or web APIs, and edges represent the bidirectional connections of actors' systems via web APIsor the web APIs offered by a firm. The node's size and label relate to the number of edges the node has. Colored nodes are actors and their color indicates the type of services they offer, while web API nodes are grey.

We obtained a range of network measurements that helped us to understand the dynamic of the ecosystem structure. The average degree refers to the average number of connections each actor has. The network diameter tells us how many steps are necessary to get from one side of the network to the other. The average path length shows the number of steps along the shortest paths for all possible pairs of networks nodes. We used Force-atlas2 as a network layout that is particularly useful to visualize a hub around a central node (Jacomy et al., 2014). In turn, the distance between nodes is related to the number of connections one node has, making it easy to visualize hubs.

We complemented this analysis with multiple corpora of archival data, seeking a granular understanding of the role of web APIs over time. The Skift interviews (Schaal, 2016, 2014) help us understand the early day of the ecosystem from voices of its key players. We selected 227 articles from Skift, PhocusWire, and other relevant travel publishers, classifying them by topic in seven categories: background, ecosystem, web APIs, actors, new services, back-end, and front-end. We also analyzed 386 web API owners' websites on the WayBack Machine to understand their services, characteristics of the web APIs offered, capabilities and roles.

The careful reading of these corpora allowed us to build a rich case study of the dynamics of the ecosystem over 26 years, and the role of web APIs in fostering innovation and structuring the ecosystem. We assessed potential explanations against our corpora, building a gradual understanding of the ecosystem. These inductive processes established converging lines of evidence and theoretical propositions. We developed an in-depth case history to organize the corpus descriptively (Eisenhardt, 1989). To reduce excessive details, we then displayed our analysis in a table (Cloutier and Ravasi, 2021; Eisenhardt, 2021).

We built a chronological table that highlighted new innovations, web APIs, and co-produced services. We contrasted our chronological table with the breaking point identified on the network graph to determine whether new co-produced services impacted the ecosystem structure and actors' interdependencies. Following this, we built a descriptive table to understand more granularly what causes the reconfigurations and to seek potential explanations concerning how innovation takes place. This table-based analysis allowed us to spot changes in the role and value of web APIs.

Appendix B. Foundations and technical description of Web APIs

B.1. Foundation of the web API

An API (Application Programming Interface) is a software interface that enables software components to communicate. They remove the need to know the "inner workings of how an API's functionality is provided" (Wulf and Blohm, 2020, p. 254). By allowing software applications to capitalize on modular software components they result in network externalities driving innovation. The Android and iOS mobile phone operating systems, for example, provide APIs access to cameras and GPS components which reduce the programming costs of using these, but also lock in any app built with them to the specific operating system (Langlois and Robertson, 1992; Teece, 1986).

B.2. Technical details of web APIs

Web APIs are a specific form of API[6] built on web standards including HTTP (Berners-Lee, 1991) and using Internet connections[7] in broadly the same way as how a web browser accesses HTML website files and using similar defined patterns of communication (Fielding, 2000). Web API's endpoint software is designed to support the interactive exchange of structured HTTP messages between diverse systems over the internet (Jacobson et al., 2012). Endpoints parse these messages and trigger operations within the internal system such that the web API is agnostic to the systems they interconnect.

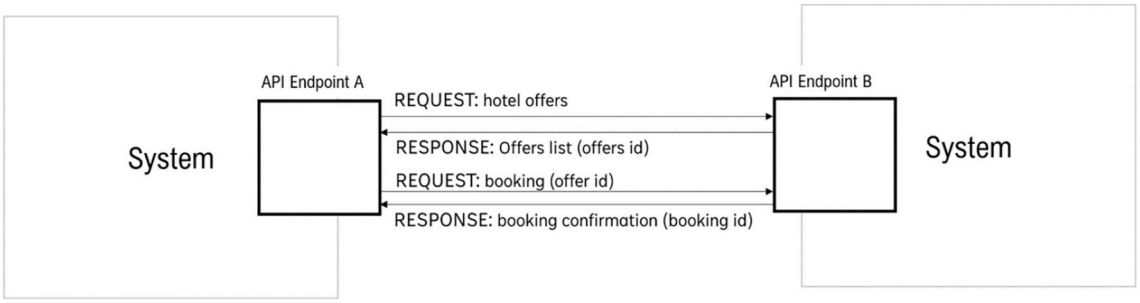

Fig. B.2.1. Web API's interactive exchange of messages for booking.

As an example, Fig. B.2.1 shows an Amadeus web API endpoint (A) to one partner's system (Endpoint B of a partner who wants to list hotel rooms). When Amadeus' partner needs a list of offers for a city, it sends a HTTP REQUEST with at least the mandatory parameters for the search (see Fig. B.2.2).[8] Amadeus' endpoint parses the REQUEST and triggers multiple operations to assemble the results which are sent back as a HTTP RESPONSE (see Fig. B.2.3). Then, the partner's endpoint processes that RESPONSE, and it can send a new REQUEST for booking one of the offers in the response. If the booking is successful, Amadeus sends a confirmation RESPONSE to its endpoint partner. This example illustrates the bi-directional and interactive exchange of messages that can deeply embed software capabilities[9] involving multiple systems and companies.

```
http://test.api.amadeus.com/v3/shopping/hotel-offers?
hotelIds = "MCLONGHM" &
adults   = 1  &
checkInDate = 2022-11-22 &
roomQuantity = 3   &
boardType = "ROOM_ONLY"  &
bestRateOnly = true
```

Fig. B.2.2. Amadeus hotel-offer API request by Amadeus' partner endpoint.

[6] Confusingly many people use the term API to refer to web APIs.

[7] Technically any connection using the telnet style protocol on TCP/IP – Transmission Control Protocol and Internet Protocol (Internet protocol suite - Wikipedia).

[8] Hotelids and Adults are mandatory parameters for the search. Hotelids' value are Amadeus property codes using 8 characters. In the example, Hotelids = "MCLONGHM" means search for the offers in London. Adults are the number of adults.

[9] Many large-scale systems such as Netflix and the BBC are modularly decomposed into microservices connected by APIs. (Balalaie, A., Heydarnoori, A., & Jamshidi, P. (2016). Microservices Architecture Enables DevOps: Migration to a Cloud-Native Architecture. Software, IEEE, 33(3), 42–52. https://doi.org/10.1109/MS.2016.64, Bradbury, D. (2016). Microservices: Small parts with big advantages. Computer Weekly, 17–21.)

```
{
  "data": [
    {
      "type": "hotel-offers",
      "hotel": {
        "type": "hotel",
        "hotelId": "HLLON101",
        "chainCode": "HL",
        "dupeId": "700027723",
        "name": "THE TRAFALGAR",
        "cityCode": "LON",
        "latitude": 51.50729,
        "longitude": -0.12889
      },
      "available": true,
      "offers": [
        {
          "id": "1BCMABM7A8",
          "checkInDate": "2021-11-20
          "checkOutDate": "2021-11-2
          "rateCode": "RAC",
          "rateFamilyEstimated": {
            "code": "PRO",
            "type": "P"
          },
          "commission": {
            "percentage": "8.00"
          },
          "room": {
            "type": "M1K",
            "typeEstimated": {
              "category":
"STANDARD_ROOM",
              "beds": 1,
              "bedType": "KING"
            },
            "description": {
              "text": "ADVANCE
PURCHASE\nTRAFALGAR KING ROOM\nCOMP
WIFI/COFFEE-TEA FACILITIES/USB PORT
              "lang": "EN"
            }
          },
          "guests": {
            "adults": 1
          },
          "price": {
            "currency": "GBP",
            "base": "300.00",
            "total": "300.00",
            "taxes": [
              {
                "code": "TOTAL_TAX"
                "amount": "0.00",
                "currency": "GBP",
                "included": true
              }
            ],
```


Fig. B.2.3. Amadeus hotel-offer API response (truncated).

B.3. Standardization of web API fabric technology

The responses from web APIs are received in XML or JSON files that are usually easy for humans to understand.[10] For example, from Fig. B.3.1 showing JSON it is clearly possible to see that a hotel "THE TRAFALGAR" in city "LON" is available for booking on the 20th of November 2021 at a commission of 8 % for a STANDARD_ROOM with a KING bed. The price is £300GBP at a "Non-refundable rate". Indeed, "if a [web] API is in some way difficult to consume, [web] API consumers can just move on to the next API offered by a different API provider, competition is much tougher" (Biehl, 2015, p. 56). This competition also results in companies that offer web APIs providing code examples and support documentation to assist the programmer with this parsing task. Such efforts are also supported by the rise of API Management systems[11] that assist with this but also often support monetization of APIs so that companies can easily charge per-call fees; something significant in the travel ecosystem during the later periods of our analysis.

Given the rather readable, understandable, and supported nature of web APIs, it is not difficult to update an endpoint software to accommodate new or alternative endpoints from different providers of the same service making many web APIs relatively easy to imitate. Take for example Fig. B.3.1 below which shows the RESPONSE message structures that Google (left) and Trivago (right) require from any company (e.g., an OTA) wishing to list their inventory on these metasearch websites. While Google's is in XML and Trivago is in JSON, it is relatively easy for a company to write software code to parse these or indeed any of the other Web APIs listing inventory, be they Expedia,[12] Agoda OTA,[13] TripAdvisor,[14] Trivago,[15] Derby,[16] or

[10] Both XML and JSON formats provide detail of the data structure and type of data alongside the data itself. This makes them extremely easy to understand and parse. Note that the design goal of XML was "It shall be easy to write programs which process XML documents" (Extensible Markup Language (XML) 1.0 (Fifth Edition) (w3.org)) - they are designed to be easy to convert and use. JSON is very similar to XML but less verbose and is easier to convert straight into JavaScript objects widely used on the web.

[11] E.g., Apigee, 3scale, Boomi and MuleSoft. Prominent features of such systems include; managing web API documentation, security, assisting API users, ensuring backward compatibility, and reporting on usage.

[12] https://developer.expediapartnersolutions.com/documentation/rapid-shopping-docs-3/#/Shopping/getAvailability

[13] https://www.agodaconnectivity.com/documentation/ycs-5-api/get-rates-availability-multi-occupancy

[14] https://developer-tripadvisor.com/connectivity-solutions/hotel-availability-check-api/documentation/hotel_availability

[15] https://developer.trivago.com/expressbooking/booking-availability.html

[16] https://developer.derbysoft.com/go/api/go-distributor-api-v4-1/availabilitypeer

HotelBeds Channel Manager.[17] Endpoint software can thus switch between providers or connect to multiple providers with little change to internal systems.

Fig. B.3.1. Google and Trivago hotel search API responses.

Appendix C. Sources

C.1. Online articles (Skift, PhocusWire, others)

Id	Year	Source	Category
SK1	2012	https://skift.com/2012/07/09/kayak-hybrid-dismisses-threat-Google-travel-ipo-materials/	Metasearch
SK2	2012	https://skift.com/2012/08/22/kayak-expands-direct-booking-with-expedia-hertz-avisbudget-and-getaroom/	Metasearch
SK3	2013	https://skift.com/2013/01/31/Facebook-interview-graph-search-to-add-hotels-and-social-signals-to-fine-tune-results/	Facebook
SK4	2014	https://skift.com/2014/11/18/the-startup-businesses-built-around-the-airbnb-ecosystem/	Ecosystem
SK5	2014	https://research.skift.com/report/travel-metasearch-whats-coming-next/	Metasearch
SK6	2014	https://skift.com/2014/02/06/expedia-has-strong-q4-thanks-to-its-new-metasearch-business-and-increased-bookings/	Metasearch
SK7	2014	https://skift.com/2014/07/21/the-next-chapter-in-convergence-of-booking-sites-and-metasearch/	Metasearch
SK8	2015	https://research.skift.com/report/the-state-of-travel-metasearch-in-2015/	Metasearch
SK9	2015	https://skift.com/2015/03/25/will-rethinking-metasearch-increase-direct-bookings-for-hotels/	Metasearch
SK10	2016	https://skift.com/2016/02/23/new-skift-trends-report-how-to-harness-the-Facebook-ecosystem-in-2016/	Facebook
SK11	2017	https://skift.com/2017/03/29/how-the-rise-of-the-api-economy-is-changing-the-way-travel-brands-do-business/	APIs
SK12	2017	https://research.skift.com/report/a-deep-dive-into-Facebooks-impact-on-travel/	Facebook
SK13	2017	https://skift.com/2017/07/10/hotel-and-online-travel-agency-direct-booking-winners-and-losers-in-5-charts/	Front-end
SK14	2017	https://skift.com/2017/12/19/new-skift-research-report-a-deep-dive-into-the-Google-travel-ecosystem-2018/	Google
SK15	2017	https://skift.com/2017/12/26/Google-hotels-ads-could-make-gains-with-chain-loyalty-rates/	Google
SK16	2018	https://skift.com/2018/03/06/Facebook-is-launching-trip-planning-ad-product-to-compete-with-Google-and-tripadvisor/	Facebook
SK17	2018	https://skift.com/2018/07/18/tripactions-expands-globally-with-a-focus-on-service/	TripAdvisor
SK18	2018	https://skift.com/2018/08/07/the-biggest-inventory-challenges-for-online-booking-sites-latest-from-skift-research/	actors

(*continued on next page*)

[17] https://developer.hotelbeds.com/documentation/hotels/booking-api/api-reference/#operation/availability

(*continued*)

Id	Year	Source	Category
SK19	2018	https://skift.com/2018/11/20/airbnb-creates-niches-for-a-new-generation-of-vacation-rental-startups-skift-research-e-book/	Airbnb
SK20	2018	https://skift.com/2018/06/12/global-distribution-systems-retool-for-the-next-digital-revolution/	APIs
SK21	2018	https://skift.com/2018/11/30/how-real-time-transparent-bidding-can-fix-a-broken-travel-search-ecosystem/	Bidding
SK22	2018	https://skift.com/2018/10/16/uber-airbnb-and-lyft-are-setting-up-2019-as-a-landmark-year-in-travel-ipos/	Ecosystem
SK23	2018	https://skift.com/2018/02/06/Google-is-more-aggressively-connecting-its-flight-and-hotel-products/	Google
SK24	2018	https://skift.com/2018/04/27/Google-plans-to-string-its-travel-assets-together/	Google
SK25	2018	https://skift.com/2018/09/27/Googles-conflicted-travel-strategy-pushes-forward/	Google
SK26	2018	https://skift.com/2018/06/12/expedia-is-closing-gap-with-booking-on-cloud-based-and-search-engine-tech/	OTA
SK27	2019	https://research.skift.com/report/the-hotel-revenue-management-landscape-2019/	Back-end
SK28	2019	https://skift.com/2019/08/28/scalability-is-key-to-driving-adoption-of-new-distribution-capability-standards/	Ecosystem
SK29	2019	https://skift.com/2019/04/16/Google-maps-is-ready-to-transform-the-world-of-superapps-a-skift-deep-dive/	Google
SK30	2019	https://skift.com/2019/05/07/Google-expands-power-over-local-discovery-and-travel-tools/	Google
SK31	2020	https://skift.com/2020/02/18/Googles-customized-travel-search-features-receive-massive-traffic-in-the-u-s-new-skift-research/	Actors
SK32	2020	https://research.skift.com/report/the-hotel-property-management-systems-landscape-2020/	Back-end
SK33	2020	https://skift.com/2020/01/21/how-new-entrants-are-shaking-up-the-hotel-property-management-space-new-skift-research/	Back-end
SK34	2020	https://skift.com/2020/01/28/how-the-cloud-is-shaking-up-hotel-property-management-tech-new-skift-research/	Back-end
PW1	2009	https://www.phocuswire.com/Will-Google-Wave-kill-the-trip-planning-sites	Google
PW2	2010	https://www.phocuswire.com/Diller-Google-faces-antitrust-issues-on-search-neutrality	Google
PW3	2020	https://www.phocuswire.com/Travel-industry-reacts-to-Google-antitrust-probe-in-the-US	Google
PW4	2010	https://www.phocuswire.com/Ten-tips-for-better-revenue-management-in-independent-hotels	Back-end
PW5	2010	https://www.phocuswire.com/Part-One-of-Three-A-guide-to-traditional-vs-dynamic-pricing-in-travel	Dynamic pricing
PW6	2010	https://www.phocuswire.com/Part-Three-of-Three-A-guide-to-traditional-vs-dynamic-pricing-in-travel	Dynamic pricing
PW7	2010	https://www.phocuswire.com/Part-Two-of-Three-A-guide-to-traditional-vs-dynamic-pricing-in-travel	Dynamic pricing
PW8	2011	https://www.programmableweb.com/news/lots-opportunities-to-dive-travel-apis/2011/06/21	APIS
PW9	2012	https://www.phocuswire.com/How-to-pre-open-a-hotel-Part-Two-of-Two-distribution-revenue-management-sales-	Back-end
PW10	2012	https://www.phocuswire.com/Ten-more-tips-for-picking-the-best-channel-management-technology-for-hotels	Back-end
PW11	2013	https://www.phocuswire.com/Growing-online-HotelRunner-bridges-digital-divide-for-lower-tier-hotels	Back-end
PW12	2013	https://www.phocuswire.com/Hotel-distribution-500-shades-of-mostly-grey	Back-end
PW13	2013	https://www.phocuswire.com/Hotels-are-upping-B2B-cloud-and-B2C-mobile-transitions	Back-end
PW14	2013	https://www.phocuswire.com/The-new-reality-in-hotel-revenue-management-a-check-list-for-2013	Back-end
PW15	2013	https://www.phocuswire.com/Travel-DISTRIBUTION-roundup-Travelport-Amadeus-SiteMinder-Vayant	Back-end
PW16	2013	https://www.phocuswire.com/Koddi-helps-digital-marketers-max-out-their-Google-Hotel-Price-Ads	Google
PW17	2014	https://www.phocuswire.com/Amadeus-and-the-new-long-game-in-hotel-technology	Back-end
PW18	2014	https://www.phocuswire.com/Hotel-tech-provider-SiteMinder-secures-30M-in-capital-from-Facebook-investor	Back-end
PW19	2014	https://www.phocuswire.com/In-depth-the-global-disruption-in-hotel-channel-managers	Back-end
PW20	2014	https://www.phocuswire.com/Pivotal-moments-in-2014-when-Sabre-changed-its-tune-over-NDC	Back-end
PW21	2014	https://www.phocuswire.com/Online-travel-agents-vs-hotels-friends-enemies-or-frenemies	Bidding
PW22	2014	https://www.phocuswire.com/GDS-hotel-bookings-via-Expedia-growth-but-for-how-long	Ecosystem
PW23	2014	https://www.phocuswire.com/Pivotal-moments-in-2014-when-Airbnb-got-in-bed-with-Concur	Ecosystem
PW24	2014	https://www.phocuswire.com/Priceline-boosts-its-revenue-thanks-to-Kayak-but-says-no-to-TripAdvisors-instant-booking	Metasearch
PW25	2016	https://www.phocuswire.com/TravelClick-debuts-a-media-suite-revamps-its-booking-engine-and-looks-at-reputation-management	Back-end
PW26	2018	https://www.phocuswire.com/Metasearch-part-2-meta-book	Metasearch
PW27	2019	https://www.phocuswire.com/marriott-expedia-wholesale-rate-distribution	Back-end
PW28	2020	https://www.phocuswire.com/unboxing-revenue-management-from-revenue-systems-to-revenue-strategy	Back-end
PW29	2020	https://www.phocuswire.com/Revenue-managers-who-play-a-pivotal-role-in-demand-generation-will-transform-their-careers	Back-end
PW30	2021	https://www.phocuswire.com/What-is-the-early-impact-of-Google-free-booking-links-for-hotels	Google
PW31	2021	https://www.phocuswire.com/kayak-opening-hotel-develop-hotel-tech-in-partnership-with-life-house	Metasearch
PW32	2021	https://www.phocuswire.com/Metasearch-travel-marketing-channel-growing	Metasearch
OT1	2015	https://www.programmableweb.com/news/top-10-travel-apis-uber-tripadvisor-and-expedia/analysis/2015/04/24	APIs
OT2	2018	https://www.altexsoft.com/blog/engineering/custom-channel-management-apis-and-services-for-widest-hotel-room-distribution/	APIs
OT3	2020	https://www.altexsoft.com/blog/engineering/travel-and-booking-apis-for-online-travel-and-tourism-service-providers/	APIs
OT4	2020	https://amadeus.com/documents/en/travel-industry/report/online-travel-2020-evolve-expand-expire.pdf	Back-end
OT5	2020	https://corporate.amadeus.com/documents/en/resources/corporate-information/corporate-documents/global-reports/2018/amadeus-global-report-2018.pdf	Back-end
OT6	2021	https://www.altexsoft.com/blog/hotel-booking-engine/	Back-end
OT7	2021	https://www.altexsoft.com/blog/opera-pms-integration/	Back-end
OT8	2021	https://www.altexsoft.com/blog/pos-hotels/	Back-end
OT9	2021	https://www.altexsoft.com/blog/hotel-search-engines/	Metasearch
OT10	n.d.	https://github.com/IsmaelMartinez/TravelResources	APIs
OT11	2019	https://www.programmableweb.com/news/10-most-popular-travel-apis/brief/2019/04/15	APIs
OT12	n.d.	https://www.reutersevents.com/travel/sites/default/files/hospitality_distribution_report_draft4_1.pdf	Metasearch
OT13	2020	https://www.youtube.com/channel/UCwI48vMwtiE-hra2RAtk1PQ	APIs
OT14	2013	https://techcrunch.com/2013/01/15/following-opentable-deal-restaurant-data-provider-locu-adds-more-big-name-partners-tripadvisor-and-citysearch/	APIs
OT15	2017	https://fortune.com/2017/07/11/tripadvisor-deliveroo-partnership-food-vacation/	APIs
OT16	n.d.	https://amadeus.com/en/portfolio/business-travel-agencies/mobile-messenger	APIs

C.2. Interviews used

IN1 Schaal, D. (2017). The Definitive Oral History of Online Travel. Retrieved from https://skift.com/history-of-online-travel/.
IN2 Schaal, D. (2015). Future of Travel Booking: Interviews With CEOs of the World's Top Online Booking Companies. Skift. Retrieved from

https://skift.com/insight/the-future-of-travel-booking/

C.3. WayBack machine

Id	Actor	Type	Year	Link
WM1	Ihotelier	Back-end	1997	https://web.archive.org/web/20001019081605/http://www.ihotelier.com/
WM2	Webrezpro	Back-end	2000	https://web.archive.org/web/*/https://www.webrezpro.com/integration-partners/ https://web.archive.org/web/*/https://www.webrezpro.com/integration-types/ https://web.archive.org/web/*/ https://web.archive.org/web/*/
WM3	Synxis	Back-end	2005	https://web.archive.org/web/*/https://reservations.synxis.com
WM4	Checkfront	Back-end	2010	https://web.archive.org/web/*/http://api.checkfront.com/ https://web.archive.org/web/*/https://www.checkfront.com/addons
WM5	Bookingsync	Back-end	2011	https://web.archive.org/web/*/http://developers.bookingsync.com/
WM6	Dolphin-Dynamics	Back-end	2011	https://web.archive.org/web/*/https://www.dolphind.com/
WM7	Reviewpush	Back-end	2011	https://web.archive.org/web/*/https://www.reviewpush.com/ https://web.archive.org/web/*/https://www.reviewpush.com/pricing-partners/
WM8	Supersaas	Back-end	2011	https://web.archive.org/web/*/https://www.supersaas.com/info/dev
WM9	Hotelston	Back-end	2012	https://web.archive.org/web/*/https://www.hotelston.com/about/api.jsf
WM10	Revel	Back-end	2012	https://web.archive.org/web/*/https://revelsystems.com/
WM11	Singleplatform	Back-end	2013	https://web.archive.org/web/*/https://singleplatform.com/
WM12	Cloudhotelier	Back-end	2017	https://web.archive.org/web/20120117044127/http://www.cloudhotelier.com/en https://github.com/cloudhotelier/api
WM13	Narnoo	Back-end	2018	https://web.archive.org/web/*/https://narnoocom.github.io/api-documentation/ https://web.archive.org/web/*/https://support.narnoo.com/article/agents-practical-guide-to-using-the-gateway/
WM14	Revato	Back-end	2019	https://web.archive.org/web/*/https://www.revato.com/
WM15	Derbysoft	Channel manager	2002	https://web.archive.org/web/*/http://derbysoft.com/ https://web.archive.org/web/*/https://developer.derbysoft.com/ https://web.archive.org/web/*/https://www.derbysoft.com/about/metasearch-channels/ https://web.archive.org/web/*/https://www.derbysoft.com/about/connectivity-partners/
WM16	Travelclick	Channel manager	2002	https://web.archive.org/web/20020326174950/http://travelclick.com/ https://web.archive.org/web/20170361575033/api.travelclick.com
WM17	Siteminder	Channel manager	2008	https://web.archive.org/web/*/http://www.siteminder.com https://web.archive.org/web/20090306083943/http://www.siteminder.com https://web.archive.org/web/20090219194447/http://siteminder.com.au/siteminder/channelmanager.html https://web.archive.org/web/20101023011944/http://www.siteminder.com/products/the-channel-manager https://web.archive.org/web/20120505021642/http://www.siteminder.com/products/the-channel-manager/ https://web.archive.org/web/20120329202839/http://www.siteminder.com/integrations/property-management-system/ https://web.archive.org/web/20150317235928/http://www.siteminder.com/integrations/ https://web.archive.org/web/20161119135833/http://www.siteminder.com/channel-manager/ https://web.archive.org/web/20190407231925/https://www.siteminder.com/integrations/
WM18	E4jconnect	Channel manager	2009	https://web.archive.org/web/*/https://e4jconnect.com/list-booking-channels https://web.archive.org/web/*/https://e4jconnect.com/support-e4jconnect/vik-channel-manager-documentation
WM19	Provab	Channel manager	2011	https://web.archive.org/web/*/https://www.provab.com/hotel-api-provider.html https://web.archive.org/web/*/https://www.provab.com/hotelapishotelapihotelxmlgtahotelbedsdotw.html ://www.provab.com/booking-com-api-integration.html https://web.archive.org/web/*/https://www.provab.com/expedia-api-integration.html https://web.archive.org/web/*/https://www.provab.com/hotelbeds-api-integration.html https://web.archive.org/web/*/https://www.provab.com/hotelspro-api-integration.html https://web.archive.org/web/*/https://www.provab.com/amadeus-gds-system.html
WM20	Toast	Channel manager	2011	https://web.archive.org/web/*/https://pos.toasttab.com/integrations
WM21	Beds25	Channel manager	2012	https://web.archive.org/web/*/https://www.beds24.com/ https://web.archive.org/web/*/https://api.beds24.com/
WM22	Clerk	Channel manager	2012	https://web.archive.org/web/*/https://www.clerkhotel.com/ https://web.archive.org/web/*/https://www.clerkhotel.com/sales/en-channel-manager/ https://web.archive.org/web/*https://www.clerkhotel.com/en/api-docs/
WM23	Littlehotelier	Channel manager	2012	https://web.archive.org/web/*/https://help.littlehotelier.com/s/article/implement-LH-rates-API?language=en_US https://web.archive.org/web/*/https://www.littlehotelier.com/channel-manager/ https://web.archive.org/web/*/https://www.littlehotelier.com/hotel-booking-engine/ https://web.archive.org/web/*/https://www.littlehotelier.com/hotel-payment-processing/
WM24	Myallocator	Channel manager	2012	https://web.archive.org/web/*/https://www.myallocator.com/pms-connections/ https://web.archive.org/web/*/https://www.myallocator.com/channels/ https://web.archive.org/web/*/https://apidocs.myallocator.com/
WM25	Travolutionary	Channel manager	2012	https://web.archive.org/web/*/http://travolutionary.com/ https://web.archive.org/web/*/http://travolutionary.com/Distribution-of-hotel-product-inventory-via-API https://web.archive.org/web/*/https://carsolize.zendesk.com/hc/en-us/categories/200167679-API
WM26	Bokun	Channel manager	2013	https://web.archive.org/web/*/https://bokun.dev/ https://web.archive.org/web/*/https://www.bokun.io/features https://web.archive.org/web/*/https://www.bokun.io/affiliate-hub https://web.archive.org/web/*/https://www.bokun.io/partners
WM27	Hoteliers	Channel manager	2013	https://web.archive.org/web/*/https://company.hoteliers.com/en/ https://web.archive.org/web/*/https://company.hoteliers.com/en/solutions/gds-connector

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Id	Actor	Type	Year	Link
				https://web.archive.org/web/*/https://company.hoteliers.com/en/solutions/booking-engine https://web.archive.org/web/*/https://company.hoteliers.com/en/solutions/channel-manager
WM28	Cloudbeds	Channel manager	2014	https://web.archive.org/web/*/https://www.cloudbeds.com/ https://web.archive.org/web/*/https://www.cloudbeds.com/features/api/
WM29	Hotelspro	Channel manager	2014	https://web.archive.org/web/*/https://api2.hotelspro.com/docs/dynamic_api/index.html https://web.archive.org/web/*/https://www.hotelspro.com
WM30	Resort Data Processing	Channel manager	2015	https://web.archive.org/web/*/https://www.resortdata.com/reservations-overview/ https://web.archive.org/web/*/https://www.resortdata.com/rdpapi/
WM31	30 k	Channel manager	2018	https://web.archive.org/web/*/https://www.30k.com/milefy-api-for-obt.html https://web.archive.org/web/*/https://www.30k.com/developers.html
WM32	Impala	Channel manager	2018	https://web.archive.org/web/*/https://impala.travel/ https://web.archive.org/web/*/https://docs.impala.travel/ https://web.archive.org/web/*/https://docs.getimpala.com/
WM33	Google	Digital Platform	2011	https://web.archive.org/web/*/https://developers.Google.com/hotels/ https://web.archive.org/web/*/https://travel.google/partners/hotels
WM34	Uber	Digital Platform	2014	https://web.archive.org/web/*/https://developer.uber.com
WM35	Amadeus	Distribution	2002	https://web.archive.org/web/20021218092533/http://api.dev.amadeus.net/api/index.htm https://web.archive.org/web/20140907062704/http://sandbox.amadeus.com/apis#flights https://web.archive.org/web/20160602213739/https://sandbox.amadeus.com/ https://web.archive.org/web/20150923012417/http://sandbox.amadeus.com/api-catalog https://web.archive.org/web/*/http://sandbox.amadeus.com/apis https://web.archive.org/web/20180207135227/https://developers.amadeus.com/self-service/category/203/api-doc/9 https://web.archive.org/web/20180207135227/https://sandbox.amadeus.com/api-catalog https://web.archive.org/web/20180207135227/https://developers.amadeus.com/self-service/category/trip/api-doc/trip-purpose-prediction https://web.archive.org/web/*/http://sandbox.amadeus.com/api-catalog
WM36	Sabre	Distribution	2005	https://web.archive.org/web/*/https://developer.sabre.com/ https://web.archive.org/web/*/https://developer.sabre.com/sabre_hospitality/apis/soap_apis/hotel/property_integration https://web.archive.org/web/*/https://developer.sabre.com/docs/rest_apis/ground/search/car_availability https://web.archive.org/web/*/https://developer.sabre.com/docs/read/rest_apis/air/search/destination_finder https://web.archive.org/web/*/https://developer.sabre.com/docs/rest_apis/air/fulfill/enhanced_air_ticket/ https://web.archive.org/web/*/https://developer.sabre.com/guides/travel-agency/how-to/soap-apis-request-format https://web.archive.org/web/*/https://developer.sabre.com/docs/read/rest_apis/air/intelligence/travel_seasonality
WM37	Travelport	Distribution	2010	https://web.archive.org/web/*/https://developer.travelport.com/ https://web.archive.org/web/*/https://www.travelport.com/
WM38	Rezdy	IBE	2012	https://web.archive.org/web/*/http://www.rezdy.com/developers
WM39	Apaleo	Marketplace	2018	https://web.archive.org/web/*/https://api.apaleo.com/
WM40	Expedia	Online Booking Channel	1995	https://web.archive.org/web/20101206072718/http://developer.ean.com/ https://web.archive.org/web/*/https://developer.expediapartnersolutions.com/ https://web.archive.org/web/*/https://expediapartnersolutions.com/ https://web.archive.org/web/*/https://advertising.expedia.com/ https://web.archive.org/web/*/https://developers.expediagroup.com/supply/lodging
WM41	Kayak	Online Booking Channel	2004	https://web.archive.org/web/*/http://developer.kayak.com/ https://web.archive.org/web/20060303052951/http://developer.kayak.com/sysinteg/hotel/early-draft.html https://web.archive.org/web/*/http://api.kayak.com/ https://web.archive.org/web/*/http://www.kayak.com/labs/ https://web.archive.org/web/20090524181029/http://www.kayak.com/hotelowner
WM42	Lastminute	Online Booking Channel	2007	https://web.archive.org/web/*/http://travelocity.mashery.com/ https://web.archive.org/web/*/https://ui.awin.com/merchant-profile/10949
WM43	Travelocity	Online Booking Channel	2000	https://web.archive.org/web/*/www.travelocity.com
WM44	Agoda	Online Booking Channel	2008	https://web.archive.org/web/*/https://www.agodaconnectivity.com/ https://web.archive.org/web/*/https://content-push.agoda.com/docs/cm/properties https://web.archive.org/web/*/https://content-push.agoda.com/docs/cm/promotion
WM45	Booking.com	Online Booking Channel	2009	https://web.archive.org/web/*/https://developers.booking.com/ https://web.archive.org/web/*/https://connect.booking.com/ https://web.archive.org/web/*/https://www.booking.com/affiliate-program/
WM46	Hotels.com	Online Booking Channel	2010	https://web.archive.org/web/*/https://www.hotels.com/page/travel-affiliate-program/
WM47	Airbnb	Online Booking Channel	2011	https://web.archive.org/web/*/https://airbnb.io https://web.archive.org/web/*/https://airbnb.io/native-navigation/docs/api/
WM48	Opentable	Online Booking Channel	2011	https://web.archive.org/web/*/https://dev.opentable.com/ https://web.archive.org/web/*/https://platform.opentable.com/documentation/ https://web.archive.org/web/*/https://opentable.herokuapp.com/
WM49	Thefork	Online Booking Channel	2011	https://web.archive.org/web/*/https://www.theforkmanager.com/
WM50	Trivago	Online Booking Channel	2005	https://web.archive.org/web/*/http://developer.trivago.com/index.html https://web.archive.org/web/*/https://studio.trivago.com *https://web.archive.org/web/20110927113914/http://www.trivago.co.uk/company.php?pagetype=187 https://studiosupport.trivago.com/hc/en-us/articles/4402602284049-Can-I-connect-my-channel-manager-to-trivago-

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(*continued*)

Id	Actor	Type	Year	Link
WM51	Locu	Travel Content Platform	2011	https://web.archive.org/web/*/https://dev.locu.com/
WM52	Mews	Marketplace	2020	https://web.archive.org/web/*/https://www.mews.com/en/products/marketplace https://web.archive.org/web/*/https://mews-systems.gitbook.io/connector-api/ https://web.archive.org/web/*/https://mews-systems.gitbook.io/distributor-guide/ https://web.archive.org/web/20201205115518/https://www.mews.com/en/press/mews-raises-33million-seriesb

Appendix D. References from the appendices

Arora, S.K., Li, Y., Youtie, J., Shapira, P., 2016. Using the wayback machine to mine websites in the social sciences: A methodological resource. Journal of the Association for Information Science and Technology 67, 1904–1915. https://doi.org/10.1002/asi.23503

Baldwin, C.Y., 2021. Design Rules Volume 2: Chapter 21—Capturing Value via Strategic Bottlenecks in Digital Exchange Platforms (SSRN Scholarly Paper No. ID 3909098). Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.3909098

Basole, R.C., 2019. On the Evolution of Service Ecosystems: A Study of the Emerging API Economy, in: Maglio, P.P., Kieliszewski, C.A., Spohrer, J. C., Lyons, K., Patrício, L., Sawatani, Y. (Eds.), Handbook of Service Science, Volume II, Service Science: Research and Innovations in the Service Economy. Springer International Publishing, Cham, pp. 479–495. https://doi.org/10.1007/978-3-319-98512-1_21

Berners-Lee, T., 1991. The HTTP Protocol as Implemented In W3 [WWW Document]. URL https://www.w3.org/Protocols/HTTP/AsImplemented.html (accessed 6.13.22).

Biehl, M., 2015. API Architecture: The Big Picture for Building APIs. API University Series.

Cloutier, C., Ravasi, D., 2021. Using tables to enhance trustworthiness in qualitative research. Strategic Organization 19, 113–133. https://doi.org/10.1177/1476127020979329

Eisenhardt, K.M., 2021. What is the Eisenhardt Method, really? Strategic Organization 19, 147–160. https://doi.org/10.1177/1476127020982866

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. The Academy of Management Review 14, 532–550. https://doi.org/10.2307/258557

Evans, P.C., Basole, R.C., 2016. Revealing the API Ecosystem and Enterprise Strategy via Visual Analytics. Communications of the ACM 59, 26–28. https://doi.org/10.1145/2856447

Fielding, R.T., 2000. Architectural Styles and the Design of Network-based Software Architectures. University of California, Irvine.

Gawer, A., 2020. Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces. Long Range Planning 102,045. https://doi.org/10.1016/j.lrp.2020.102045

Gregory, R.W., Henfridsson, O., Kaganer, E., Kyriakou, H., 2021. The Role of Artificial Intelligence and Data Network Effects for Creating User Value. AMR 46, 534–551. https://doi.org/10.5465/amr.2019.0178

Iansiti, M., Levien, R., 2004. Strategy as Ecology. Harvard Business Review 82, 68–78.

Iyer, B., Lee, C.-H., Venkatraman, N., 2006. Managing in a "Small World Ecosystem": Lessons from the Software Sector. California Management Review 48, 28–47. https://doi.org/10.2307/41166348

Iyer, B.R., Basole, R.C., 2016. Visualization to understand ecosystems. Communications of the ACM 59, 27–30. https://doi.org/10.1145/3000610

Jacobson, D., Brail, G., Woods, D., 2012. APIs: A Strategy Guide. O'Reilly Media, Inc.

Jacomy, M., Venturini, T., Heymann, S., Bastian, M., 2014. ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software. PLOS ONE 9, e98679. https://doi.org/10.1371/journal.pone.0098679

Langlois, R.N., Robertson, P.L., 1992. Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries. Research Policy 21, 297–313. https://doi.org/10.1016/0048-7333(92)90030-8.

Schaal, D., 2016. The Definitive Oral History of Online Travel [WWW Document]. Skift. URL https://skift.com/history-of-online-travel/ (accessed 5.3.20).

Schaal, D., 2014. Future of Travel Booking: Interviews With CEOs of the World's Top Online Booking Companies [WWW Document]. Skift. URL https://skift.com/insight/the-future-of-travel-booking/ (accessed 7.28.21).

Shipilov, A., Gawer, A., 2019. Integrating Research on Interorganizational Networks and Ecosystems. ANNALS 14, 92–121. https://doi.org/10.5465/annals.2018.0121

Teece, D.J., 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy 15, 285–305. https://doi.org/10.1016/0048-7333(86)90027-2.

Valderrama, E., 2020. Social media platforms as economic organizations: reconstructing the evolution of TripAdvisor's operations (phd). London School of Economics and Political Science.

Wulf, J., Blohm, I., 2020. Fostering Value Creation with Digital Platforms: A Unified Theory of the Application Programming Interface Design. Journal of Management Information Systems 37, 251–281. https://doi.org/10.1080/07421222.2019.1705514

References

Adner, R., 2006. Match your innovation strategy to your innovation ecosystem. Harv. Bus. Rev. 12.

Adner, R., 2017. Ecosystem as structure: an actionable construct for strategy. J. Manag. 43, 39–58. https://doi.org/10.1177/0149206316678451.

Alaimo, C., Kallinikos, J., Valderrama, E., 2020. Platforms as service ecosystems: lessons from social media. J. Inf. Technol. 35, 25–48. https://doi.org/10.1177/0268396219881462.

Alexander, C., Ishikawa, S., Silverstein, M., 1977. A Pattern Language: Towns, Buildings, Construction. Oxford University Press, Oxford, New York, Center for Environmental Structure Series.

API Evangelist, 2012. History of APIs [WWW document]. API Evangelist. URL. https://apievangelist.com/2012/12/20/history-of-apis/ (accessed 4.5.22).

Baldwin, C.Y., 2019. Design Rules, Volume 2: How Technology Shapes Organizations: Chapter 13 Platform Systems vs. Step Processes - The Value of Options and the Power of Modularity (SSRN Scholarly Paper No. ID 3320494). Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.3320494.
Baldwin, C.Y., 2021. Design Rules Volume 2: Chapter 21—Capturing Value via Strategic Bottlenecks in Digital Exchange Platforms (SSRN Scholarly Paper No. ID 3909098). Science Research Network, Rochester, NY, Social. https://doi.org/10.2139/ssrn.3909098.
Baldwin, C.Y., Clark, K.B., 2000. Design Rules: The Power of Modularity. The MIT Press.
Baldwin, C.Y., Clark, K.B., 2006. Modularity in the design of complex engineering systems. In: Braha, D., Minai, A.A., Bar-Yam, Y. (Eds.), Complex Engineered Systems: Science Meets Technology. Understanding Complex Systems. Springer, Berlin Heidelberg, Berlin, Heidelberg, pp. 175–205. https://doi.org/10.1007/3-540-32834-3_9.
Baldwin, C.Y., Woodard, C.J., 2009. The architecture of platforms: a unified view. In: Gawer, A. (Ed.), Platforms, Markets and Innovation. Edward Elgar, Cheltenham, UK, pp. 19–44.
Barrett, M., Davidson, E., Prabhu, J., Vargo, S.L., 2015. Service innovation in the digital age: key contributions and future directions. MIS Q. 39, 135–154.
Basole, R.C., 2019. On the evolution of service ecosystems: a study of the emerging API economy. In: Maglio, P.P., Kieliszewski, C.A., Spohrer, J.C., Lyons, K., Patrício, L., Sawatani, Y. (Eds.), Handbook of Service Science, vol. II. Springer International Publishing, Cham, pp. 479–495. https://doi.org/10.1007/978-3-319-98512-1_21. Service Science: Research and Innovations in the Service Economy.
Bharadwaj, A., El Sawy, O.A., Pavlou, P.A., Venkatraman, N., 2013. Digital business strategy: toward a next generation of insights. MIS Q.: Manag. Inf. 37, 471–482. https://doi.org/10.25300/MISQ/2013/37:2.3.
Bloomberg Intelligence, 2016. Online Travel M&a in Focus in OTA Market. Bloomberg Professional Services.
Bogers, M., West, J., 2012. Managing distributed innovation: strategic utilization of open and user innovation. Creat. Innov. Manag. 21, 61–75. https://doi.org/10.1111/j.1467-8691.2011.00622.x.
Bogers, M., Sims, J., West, J., 2019. What is an ecosystem? Incorporating 25 years of ecosystem research. Acad. Manag. Proc. 2019, 11080. https://doi.org/10.5465/AMBPP.2019.11080abstract.
Bresnahan, T.F., Greenstein, S., 1999. Technological competition and the structure of the computer industry. J. Ind. Econ. 47, 1–40.
Brynjolfsson, E., Mcafee, A., 2014. The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies, Illustrated, edition. ed. W. W. Norton & Company, New York.
Cabigiosu, A., Zirpoli, F., Camuffo, A., 2013. Modularity, interfaces definition and the integration of external sources of innovation in the automotive industry. Res. Policy 42, 662–675. https://doi.org/10.1016/j.respol.2012.09.002.
Campbell-Kelly, M., 2003. From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry. MIT Press.
Castillo-Manzano, J.I., López-Valpuesta, L., 2010. The decline of the traditional travel agent model. Transp. Res. E Logist. Transp. Rev. 46, 639–649. https://doi.org/10.1016/j.tre.2009.12.009.
Ceccagnoli, M., Forman, C., Huang, P., Wu, D.J., 2012. Cocreation of value in a platform ecosystem: the case of Enterprise software. MIS Q. 36, 263–290. https://doi.org/10.2307/41410417.
Chandler, A., 1977. The Visible Hand: Managerial Revolution in American Business: The Managerial Revolution in American Business. Harvard University Press, Cambridge, Mass.
Chesbrough, H.W., 2003. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School, Boston, Massachusetts.
Clough, D.R., Wu, A., 2022. Artificial Intelligence, data-driven learning, and the decentralized structure of platform ecosystems. Acad. Manage. Rev. 47, 184–189. https://doi.org/10.5465/amr.2020.0222.
Cloutier, C., Ravasi, D., 2021. Using tables to enhance trustworthiness in qualitative research. Strateg. Organ. 19, 113–133. https://doi.org/10.1177/1476127020979329.
Colfer, L.J., Baldwin, C.Y., 2016. The mirroring hypothesis: theory, evidence, and exceptions. Ind. Corp. Chang. 25, 709–738. https://doi.org/10.1093/icc/dtw027.
Copeland, D.G., McKenney, J.L., 1988. Airline reservations systems: lessons from history. MIS Q. 12 (3), 353–370. https://doi.org/10.2307/249202.
de Reuver, M., Sørensen, C., Basole, R.C., 2018. The digital platform: a research agenda. J. Inf. Technol. 33, 124–135. https://doi.org/10.1057/s41265-016-0033-3.
Delgado, P., 2019. How Metasearch Became the most Important Marketing Channel in Travel [WWW Document]. PhocusWire, URL. https://www.phocuswire.com/Meta search-travel-marketing-channel-growing. accessed 4.4.22.
Eaton, B., Elaluf-Calderwood, S., Sørensen, C., Yoo, Y., 2015. Distributed tuning of boundary resources: the case of Apple's iOS service system. MIS Q. 39, 217–243.
Eisenhardt, K.M., 1989. Building theories from case study research. Acad. Manag. Rev. 14, 532–550. https://doi.org/10.2307/258557.
Eisenhardt, K.M., 2021. What is the Eisenhardt method, really? Strateg. Organ. 19, 147–160. https://doi.org/10.1177/1476127020982866.
Eisenmann, T., Parker, G., Alstyne, M.W.V., 2006. Strategies for two-sided markets. Harv. Bus. Rev. 84, 12.
Eisenmann, T.R., Parker, G., Alstyne, M.V., 2009. Opening platforms: How, when and why? In: Gawer, A. (Ed.), Platforms. Markets and Innovation. Edward Elgar Publishing.
Evan, W.M., Olk, P., 1990. R&D consortia: a new U.S. organizational form. Sloan Manage. Rev. 31, 37.
Evans, P.C., Basole, R.C., 2016. Revealing the API ecosystem and enterprise strategy via visual analytics. Commun. ACM 59, 26–28. https://doi.org/10.1145/2856447.
Expedia Group, n.d. The Power of the Platform. https://www.expediagroup.com/who-we-are/our-story/default.aspx (accessed 22.3.23).
Farrell, J., Saloner, G., 1992. Converters, compatibility, and the control of interfaces. J. Ind. Econ. 40, 9–35. https://doi.org/10.2307/2950625.
Freeman, C., 2007. The ICT paradigm. In: Mansell, R., Avgerou, C., Quah, D., Silverstone, R. (Eds.), The Oxford Handbook of Information and Communication Technologies. Oxford University Press, Oxford, pp. 34–54.
Furr, N., Shipilov, A., 2018. Building the right ecosystem for innovation. MIT Sloan Manag. Rev. 59, 59–64.
Gao, L.S., Iyer, B., 2006. Analyzing complementarities using software stacks for software industry acquisitions. J. Manag. Inf. Syst. 23, 119–147.
Gawer, A. (Ed.), 2009. Platforms, Markets and Innovation. Edward Elgar, Cheltenham, UK.
Gawer, A., 2014. Bridging differing perspectives on technological platforms: toward an integrative framework. Res. Policy 43, 1239–1249. https://doi.org/10.1016/j.respol.2014.03.006.
Gawer, A., 2020. Digital platforms' boundaries: the interplay of firm scope, platform sides, and digital interfaces. Long Range Plann. 102045 https://doi.org/10.1016/j.lrp.2020.102045.
Gawer, A., Cusumano, M.A., 2002. Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation, Illustrated, Edition. ed. Harvard Business Review Press, Boston, Mass.
Gawer, A., Cusumano, M.A., 2014. Industry platforms and ecosystem innovation. J. Prod. Innov. Manag. 31, 417–433. https://doi.org/10.1111/jpim.12105.
Ghazawneh, A., Henfridsson, O., 2013. Balancing platform control and external contribution in third-party development: the boundary resources model. Inf. Syst. J. 23, 173–192. https://doi.org/10.1111/j.1365-2575.2012.00406.x.
Gregory, R.W., Henfridsson, O., Kaganer, E., Kyriakou, S.H., 2021. The role of artificial intelligence and data network effects for creating user value. Acad. Manage. Rev. 46, 534–551. https://doi.org/10.5465/amr.2019.0178.
Gregory, R.W., Henfridsson, O., Kaganer, E., Kyriakou, H., 2022. Data network effects: key conditions, shared data, and the data value duality. Acad. Manage. Rev. 47, 189–192. https://doi.org/10.5465/amr.2021.0111.
Gupta, A., Panagiotopoulos, P., Bowen, F., 2020. An orchestration approach to smart city data ecosystems. Technol. Forecast. Soc. Chang. 153, 119929 https://doi.org/10.1016/j.techfore.2020.119929.
Hanelt, A., Firk, S., Hildebrandt, B., Kolbe, L.M., 2021. Digital M&A, digital innovation, and firm performance: an empirical investigation. Eur. J. Inf. Syst. 30, 3–26. https://doi.org/10.1080/0960085X.2020.1747365.
Henfridsson, O., Mathiassen, L., Svahn, F., 2014. Managing technological change in the digital age: the role of architectural frames. J. Inf. Technol. 29, 27–43. https://doi.org/10.1057/jit.2013.30.
Heshmatisafa, S., Seppänen, M., 2023. Exploring API-driven business models: lessons learned from Amadeus's digital transformation. Digital Business 3, 1–11. https://doi.org/10.1016/j.digbus.2023.100055.
Hou, H., Shi, Y., 2021. Ecosystem-as-structure and ecosystem-as-coevolution: a constructive examination. Technovation 100, 102193. https://doi.org/10.1016/j.technovation.2020.102193.
Hurmelinna-Laukkanen, P., Nätti, S., 2018. Orchestrator types, roles and capabilities – a framework for innovation networks. Ind. Mark. Manag. 74, 65–78. https://doi.org/10.1016/j.indmarman.2017.09.020.
Iansiti, M., Levien, R., 2004. Strategy as ecology. Harv. Bus. Rev. 82, 68–78.
Iyer, B.R., Basole, R.C., 2016. Visualization to understand ecosystems. Commun. ACM 59, 27–30. https://doi.org/10.1145/3000610.
Iyer, B., Lee, C.-H., Venkatraman, N., 2006. Managing in a "small world ecosystem": lessons from the software sector. Calif. Manage. Rev. 48, 28–47. https://doi.org/10.2307/41166348.
Jacobides, M.G., Cennamo, C., Gawer, A., 2018. Towards a theory of ecosystems. Strateg. Manag. J. 39, 2255–2276. https://doi.org/10.1002/smj.2904.
Jacobson, D., Brail, G., Woods, D., 2012. APIs: A Strategy Guide. O'Reilly Media, Inc.
Kapoor, R., 2018. Ecosystems: broadening the locus of value creation. J. Organ. Des. 7, 12. https://doi.org/10.1186/s41469-018-0035-4.
Krishnan, V., Gupta, S., 2001. Appropriateness and impact of platform-based product development. Manag. Sci. 47, 52–68. https://doi.org/10.1287/mnsc.47.1.52.10665.
Langley, A., Smallman, C., Tsoukas, H., Van de Ven, A.H., 2013. Process studies of change in organization and management: unveiling temporality, activity, and flow. AMJ 56, 1–13. https://doi.org/10.5465/amj.2013.4001.
Langlois, R.N., 2003. The vanishing hand: the changing dynamics of industrial capitalism. Ind. Corp. Chang. 12, 351–385.
Langlois, R.N., Robertson, P.L., 1992. Networks and innovation in a modular system: lessons from the microcomputer and stereo component industries. Res. Policy 21, 297–313. https://doi.org/10.1016/0048-7333(92)90030-8.
Langlois, R.N., Robertson, P.L., 1995. Firms. A dynamic Theory of Business Institutions. Routledge, London, Markets and Economic Change. https://doi.org/10.4324/9780203199237.
Leten, B., Vanhaverbeke, W., Roijakkers, N., Clerix, A., Van Helleputte, J., 2013. IP models to orchestrate innovation ecosystems: IMEC, a public research Institute in nano-electronics. Calif. Manage. Rev. 55, 51–64. https://doi.org/10.1525/cmr.2013.55.4.51.
Liu, Y., Dong, J., Ying, Y., Jiao, H., 2021. Status and digital innovation: a middle-status conformity perspective. Technol. Forecast. Soc. Chang. 168, 120781 https://doi.org/10.1016/j.techfore.2021.120781.
Lyytinen, K., 2022. Innovation logics in the digital era: a systemic review of the emerging digital innovation regime. Innovation 24, 13–34. https://doi.org/10.1080/14479338.2021.1938579.

Mansell, R., 2021. Adjusting to the digital: societal outcomes and consequences. Res. Policy 50, 104296. https://doi.org/10.1016/j.respol.2021.104296.
McIntyre, D., Srinivasan, A., Afuah, A., Gawer, A., Kretschmer, T., 2020. Multi-sided platforms as new organizational forms. AMP. https://doi.org/10.5465/amp.2018.0018.
Moore, J.F., 1993. Predators and prey: a new ecology of competition. Harv. Bus. Rev. 71, 75–86.
Moore, J.F., 1996. The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems. HarperBusiness.
Nambisan, S., 2013. Information technology and product/service innovation: a brief assessment and some suggestions for future research. J. Assoc. Inf. Syst. 14, 215–226.
Nambisan, S., Baron, R.A., 2013. Entrepreneurship in innovation ecosystems: entrepreneurs' self–regulatory processes and their implications for new venture success. Entrep. Theory Pract. 37, 1071–1097. https://doi.org/10.1111/j.1540-6520.2012.00519.x.
Nambisan, S., Lyytinen, K., Majchrzak, A., Song, M., 2017. Digital innovation management: reinventing innovation management research in a digital world. MIS Q. 41, 223–238.
Nambisan, S., Wright, M., Feldman, M., 2019. The digital transformation of innovation and entrepreneurship: progress, challenges and key themes. Res. Policy 48, 103773. https://doi.org/10.1016/j.respol.2019.03.018.
Niinioja, M., Moilanen, J., Seppänen, M., Honkanen, M., 2019. API Economy 101: Changes your Business.
Olk, P., West, J., 2023. Distributed governance of a complex ecosystem: how R&D consortia orchestrate the Alzheimer's knowledge ecosystem. Calif. Manage. Rev. 65, 93–128. https://doi.org/10.1177/00081256231165329.
O'Mahony, S., Karp, R., 2022. From proprietary to collective governance: how do platform participation strategies evolve? Strateg. Manag. J. 43, 530–562. https://doi.org/10.1002/smj.3150.
Orlikowski, W.J., Scott, S.V., 2008. Sociomateriality: challenging the separation of technology, work and organization. Acad. Manag. Ann. 2, 433–474. https://doi.org/10.1080/19416520802211644.
Ozcan, P., Han, S., Graebner, M., 2017. Single cases: the what, why and how. In: Mir, R., Jain, S. (Eds.), The Routledge Companion to Qualitative Research in Organization Studies. Routledge, New York, pp. 92–112.
Parker, G.G., Alstyne, M.W.V., Choudary, S.P., 2016. Platform Revolution: How Networked Markets Are Transforming the Economy and how to Make Them Work for you. W. W. Norton & Company, New York.
Parnas, D.L., 1972. On the criteria to be used in decomposing systems into modules. Commun. ACM 15, 1053–1058. https://doi.org/10.1145/361598.361623.
Pencarelli, T., 2020. The digital revolution in the travel and tourism industry. Inf. Technol. Tour. 22, 455–476. https://doi.org/10.1007/s40558-019-00160-3.
Pettigrew, A.M., 1990. Longitudinal field research on change: theory and practice. Organ. Sci. 1, 267–292.
Porter, M.E., 2008. The five competitive forces that shape strategy. Harv. Bus. Rev. 86, 78–93.
Ranganathan, R., Ghosh, A., Rosenkopf, L., 2018. Competition–cooperation interplay during multifirm technology coordination: the effect of firm heterogeneity on conflict and consensus in a technology standards organization. Strateg. Manag. J. 39, 3193–3221. https://doi.org/10.1002/smj.2786.
Reypens, C., Lievens, A., Blazevic, V., 2021. Hybrid orchestration in multi-stakeholder innovation networks: practices of mobilizing multiple, diverse stakeholders across organizational boundaries. Organ. Stud. 42, 61–83. https://doi.org/10.1177/0170840619868268.
Rochet, J.-C., Tirole, J., 2003. Platform competition in two-sided markets. J. Eur. Econ. Assoc. 1, 990–1029. https://doi.org/10.1162/154247603322493212.
Santos, W., 2019. APIs show faster growth rate in 2019 than previous years [WWW document]. In: ProgrammableWeb. https://www.programmableweb.com/news/apis-show-faster-growth-rate-2019-previous-years/research/2019/07/17. accessed 6.5.22.
Shipilov, A., Gawer, A., 2019. Integrating research on interorganizational networks and ecosystems. Annals 14, 92–121. https://doi.org/10.5465/annals.2018.0121.
Statista, 2016. Digital Travel Sales Worldwide from 2014 to 2020 [WWW Document]. Statista, URL. http://www.statista.com/statistics/499694/forecast-of-online-travel-sales-worldwide/. accessed 7.26.21.
Tan, W., Fan, Y., Ghoneim, A., Hossain, M.A., Dustdar, S., 2016. From the service-oriented architecture to the web API economy. IEEE Internet Comput. 20, 64–68. https://doi.org/10.1109/MIC.2016.74.
Teece, D.J., 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. Res. Policy 15, 285–305. https://doi.org/10.1016/0048-7333(86)90027-2.
Teece, D.J., 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strateg. Manag. J. 28, 1319–1350.
The World Bank, 2020. International Tourism, Number Of Arrivals. Data [WWW Document]. URL. https://data.worldbank.org/indicator/ST.INT.ARVL. accessed 7.26.21.
Tilson, D., Lyytinen, K., Sørensen, C., 2010. Research commentary—digital infrastructures: the missing IS research agenda. Inf. Syst. Res. 21, 748–759. https://doi.org/10.1287/isre.1100.0318.
Valderrama, E., 2020. Social Media Platforms as Economic Organisations: Reconstructing the Evolution of TripAdvisor's Operations (phd). London School of Economics and Political Science. http://etheses.lse.ac.uk/4215/.
Vargo, S.L., Maglio, P.P., Akaka, M.A., 2008. On value and value co-creation: a service systems and service logic perspective. Eur. Manag. J. 26, 145–152. https://doi.org/10.1016/j.emj.2008.04.003.
von Hippel, E., 2006. Democratizing Innovation. The MIT Press, Cambridge, Mass.
von Krogh, G., 2012. Knowledge sharing in organizations: the role of communities. In: Easterby-Smith, M., Lyles, M.A. (Eds.), Handbook of Organizational Learning and Knowledge Management. Wiley, Chichester, UK, pp. 403–432.
Vukovic, M., Laredo, J., Muthusamy, V., Slominski, A., Vaculin, R., Tan, W., Naik, V., Silva-Lepe, I., Kumar, A., Srivastava, B., Branch, J.W., 2016. Riding and thriving on the API hype cycle. Commun. ACM 59, 35–37. https://doi.org/10.1145/2816812.
Wang, P., 2021. Connecting the parts with the whole: toward an information ecology theory of digital innovation ecosystems. MIS Q. 45, 397–422. https://doi.org/10.25300/MISQ/2021/15864.
West, J., Dedrick, J., 2000. Innovation and control in standards architectures: the rise and fall of Japan's PC-98. Inf. Syst. Res. 11, 197–216. https://doi.org/10.1287/isre.11.2.197.11778.
Windrum, P., Haynes, M., Thompson, P., 2019. "Breaking the mirror": interface innovation and market capture by Japanese professional camera firms, 1955–1974. Ind. Corp. Chang. 28, 1029–1056. https://doi.org/10.1093/icc/dtz003.
Wulf, J., Blohm, I., 2020. Fostering value creation with digital platforms: a unified theory of the application programming Interface design. J. Manag. Inf. Syst. 37, 251–281. https://doi.org/10.1080/07421222.2019.1705514.
Yan, Z., Yang, H., Jia, L., Tan, Y., 2021. Asymmetric Network Effects in the Integration of Digital Platforms (SSRN Scholarly Paper No. ID 3871279). Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.3871279.
Yin, R.K., 2009. Case Study Research. Design and Methods, Fourth. ed. Sage, London.
Yoo, Y., Henfridsson, O., Lyytinen, K., 2010. The new organizing logic of digital innovation: an agenda for information systems research. Inf. Syst. Res. 21, 724–735. https://doi.org/10.1287/isre.1100.0322.
Yoo, Y., Boland, R.J., Lyytinen, K., Majchrzak, A., 2012. Organizing for innovation in the digitized world. Organization Science 23, 1398–1408. https://doi.org/10.1287/orsc.1120.0771.
Yu, S.-F., 2008. Price perception of online airline ticket shoppers. J. Air Transp. Manag. 14, 66–69. https://doi.org/10.1016/j.jairtraman.2007.11.002.