The deployment of snowmaking in the French ski tourism industry: a path development approach

Lucas Berard-Chenu, Hugues François, Samuel Morin, Emmanuelle George

Current Issues in Tourism

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rcit20

The deployment of snowmaking in the French ski tourism industry: a path development approach

Lucas Berard-Chenu, Hugues François, Samuel Morin & Emmanuelle George

To cite this article: Lucas Berard-Chenu, Hugues François, Samuel Morin & Emmanuelle George (2022): The deployment of snowmaking in the French ski tourism industry: a path development approach, Current Issues in Tourism, DOI: 10.1080/13683500.2022.2151876

To link to this article: https://doi.org/10.1080/13683500.2022.2151876

CURRENT ISSUES IN TOURISM
https://doi.org/10.1080/13683500.2022.2151876

Routledge
Taylor & Francis Group

The deployment of snowmaking in the French ski tourism industry: a path development approach

Lucas Berard-Chenu [a,b], Hugues François [a], Samuel Morin [b] and Emmanuelle George [a]

[a]Univ. Grenoble Alpes, INRAE, LESSEM, Grenoble, France; [b]Univ. Grenoble Alpes, Université de Toulouse, Météo-France, CNRS, CNRM, Centre d'Etudes de la Neige, Grenoble, France

ABSTRACT

Many mountainous regions in Europe, including their tourism sectors, show a high degree of economic specialization. The ski tourism industry forms part of the long-standing economic success of the French Alps. Over the past 20 years, snowmaking has become a key feature of ski tourism, but future climate change will decrease its effectiveness as an adaptation solution to natural snow cover reduction. However, the ski tourism industry does not seem to be intent on stopping its investment in snowmaking, which raises the question of its dependence on this technology. In this study, we employ the path development framework to examine how snowmaking development has oriented decision-making to ensure the future of the French ski tourism industry. We analysed 38 in-depth semi-directive interviews and key financial figures from the French alpine ski tourism industry. Our results show that technical progress and specific investments in snowmaking have deeply transformed the management of ski resorts. Our finding is that snowmaking spurred ski lift operators to pursue specialization in the ski tourism industry. However, because of its ambivalent effects on the ski tourism industry, we view snowmaking development both as path extension and as path contraction.

ARTICLE HISTORY
Received 27 July 2021
Accepted 18 October 2022

KEYWORDS
Path development; ski tourism industry; snowmaking; lock-ins; technical progress

Introduction

The ski tourism industry is a significant economic sector of French mountainous regions. France is one of the largest ski markets – along with the USA and Austria – with about 50 million skier visits in 2019 (Vanat, 2020). According to the industry, ski tourism provides 120,000 jobs and accounts for EUR 2 billion of French commercial exports (DSF, 2020). The ski tourism industry, as a snow-dependent economic sector, is vulnerable to climate variability and its long-term change. Through snowmaking, ski lift operators have reduced their reliance on the natural snow cover (Falk & Lin, 2018). Snowmaking is also the most popular technical adaptation to counter the decreasing trend of natural snow cover due to climate change (Abegg et al., 2007).

Despite several studies expressing cautionary statements on the ability of snowmaking to limit the impact and risks of future climate change (Hock et al., 2019) or to increase skier visits because of diminishing returns to scale (Falk & Vanat, 2016), ski lift operators have so far continued to invest in snowmaking in Europe (Abegg et al., 2017; Trawöger, 2014). Since snowmaking has mainly been studied through climate change impact studies, ski lift operators' attraction to

CONTACT Lucas Berard-Chenu lucas.berard@inrae.fr
Supplemental data for this article can be accessed online at https://doi.org/10.1080/13683500.2022.2151876

snowmaking is often characterized as a headlong rush to a technical adaptation to climate change without considering alternative solutions. However, an overall assessment of the ski tourism industry's evolution, taking account of changes caused by snowmaking over the past decade, is missing (Berard-Chenu, 2021). In response, this study analyses the development of snowmaking in the ski tourism industry in the French Alps using the path development trajectories framework, which has appeared in the field of evolutionary economic geography. Recent contributions emanating from the path development approach offer a relevant framework to understand how snowmaking has contributed to the development of the ski tourism industry. Our study explains the poorly known mechanisms and dynamics related to snowmaking. To attain this goal, it is based on a multi-method approach using a triangulation technique (Miles, 2013) to cross-check our dataset derived from different sources.

The paper is structured as follows. Section Conceptual background provides an overview of the existing literature of snowmaking technology and path development in tourism studies. It shows the opportunity and relevance to use a path development framework to analyse the dissemination of snowmaking in the ski tourism industry. Section Material and method introduces the study area, offers an overview of the data collected and presents the methodology. Section Results provides results drawn from the analysis of interviews and key financial figures. Section Discussion discusses the results while the last part, Section Conclusion, concludes the study.

Conceptual background

Snowmaking and ski tourism industry

Very few studies have analysed the economic and organizational consequences of the spread of snowmaking in the ski tourism industry since it became 'an integral part of the [ski resort] business for 20 years' (Steiger et al., 2019, p. 23). Apart from a widely held opinion that snowmaking use soared in the European Alps after a number of snow-scarce seasons at the end of the 1980s and the beginning of the 1990s (Gonseth, 2008), little is known about the drivers of snowmaking's evolution in the European ski tourism industry. Climate change issues have partly overshadowed the roles of snowmaking in the operation of ski resorts. Steiger and Mayer (2008) and Paccard (2010) identified different conditions that raised the salience snowmaking use: climate change, variability of snow precipitation (especially in early winter to meet a resort's opening date), competitive economic pressure, and the need to meet the demands of ski tourism. Among these factors, the potential of snowmaking to reduce the impacts of the snow cover's inter-annual variability and longer-term decline due to climate change has given rise to a significant body of academic literature (Steiger et al., 2019). Meanwhile, other motivations, especially the evolutions in the ski tourism industry, have been neglected. Based on qualitative interviews with ski area operators, Mayer et al. (2007) described the different snowmaking strategies according to ski areas specificities (e.g. complete snowmaking coverage, snowmaking of low-altitude slopes, at high altitudes or on glaciers, etc.). Since this pioneering study of 2007, the role of snowmaking technology in the ski tourism industry has received little attention.

More recently, Spandre et al. (2016) stated that vulnerability to snow conditions was a driver of, amongst others, the development of snowmaking facilities. Based on a survey of 55 French ski resorts, the authors highlighted that regardless of the ski resorts' size, snowmaking management relied on three factors: to satisfy the skiers' expectations, to provide technical solutions to enable uninterrupted ski lift operations, and to promote the resort. Although analysing the first two factors in depth, they assumed rather than demonstrated that promotional aims such as communicating a 'snow guarantee' as a sales pitch might influence the development of snowmaking. In addition, few studies adopted an evolutionary perspective on snowmaking technology in the ski tourism industry. Some authors mentioned technical advances introduced by snowmaking suppliers (e.g. Bicknell & Mcmanus, 2006; Campos Rodrigues et al., 2018; Morrison & Pickering, 2013; Wilson

et al., 2018) but without emphasizing their associated consequences such as the potential self-reinforcement of snowmaking use in the ski tourism industry. An assessment of lock-in effects produced by snowmaking was deemed relevant, especially being, according to Hjalager (2015), one of the hundred most important innovations in the tourism sector because it not only increases productivity and efficacy but also restructures the input factors of ski lift operators. As a result, snowmaking did not only influence snow reliability but also had underlying impacts on ski resorts. Mayer (2009) pointed out that the tourism demand took snow reliability for granted, with the result that snowmaking has become a basic constitutive factor that plays a more significant role than innovative cable car systems in the success of ski tourism. Mayer's findings suggest that snowmaking as a snow guarantee has had a positive lock-in effect on the ski tourism industry. Beyond technological improvement, snowmaking may also lock mountainous regions in development paths that will lose dynamism in case of exacerbated climate change. Although Steiger et al. (2019) and Abegg et al. (2017) assumed that continued investments in snowmaking contribute to an increasing dependency on the ski tourism industry, none of the studies employed a path development framework to analyse, with a broader scope, the development of snowmaking in the ski tourism industry.

Path development in tourism studies

Evolutionary economic geography (EEG) that aims to explain the development and change of regions or economic sectors from a dynamic perspective (Boschma & Frenken, 2006) is a powerful theoretical framework to understand the socioeconomic evolution of regions and industries (Storper, 2011). EEG initially focused on path dependence, a concept that explains the economic specialization of regions and that includes the lock-in effects that push a technology, an industry, or a regional economy along one path rather than another (Strambach, 2010). In its original form, path dependence was considered as the combination of historical contingency and the emergence of self-reinforcing effects that steer regional economies along one path rather than another, fostering continuity rather than change.

Tourism studies provide useful scope for the evolutionary economic geography approach (Williams, 2014, p. 278) and for path dependence (Brouder et al., 2016). Since the tourism area life cycle (TALC) of Butler (1980) used to be the most popular and dominant framework in tourism geography, the EEG approach emerged as a promising alternative framework to analyse the evolution of tourism destinations from a non-deterministic perspective. Specifically, path dependence can deal with the criticisms and limitations of the TALC model (Ma & Hassink, 2013). Subsequently, over the past decade, the popularity of path dependence and EEG have spilled over into tourism geographies (e.g. Brouder & Eriksson, 2013; Papatheodorou, 2004; Sanz-Ibáñez & Clavé, 2014). Nevertheless, despite the vitality of the EEG framework and path dependence in tourism studies, very few studies have employed these concepts in the context of the ski tourism industry.

Gill and Williams (2014, 2016) used an EEG approach to highlight catalysts and inhibitors of change to the Whistler (Canada) ski resort's governance. The authors showed why governance systems did not change at Whistler even though these systems did not produce an optimal situation. They furthermore showed that path-dependent forces constrained its stakeholders from making changes because of the benefits embedded in the increasing returns that result from lock-ins. Müller (2019) analysed the purchase of alpine facilities in the Tärna district in Sweden by an entertainment company and how the latter sought to increase returns on investments in alpine lift infrastructure by staying locked-in in alpine ski tourism, thus clashing with local stakeholders and tourism market conditions. In both cases, the authors only applied the path dependence framework to single ski resort case studies. To date, path dependence contributions in the ski tourism industry have focused mainly on the organization of destination marketing without addressing the evolution of the tourism supply as an issue.

The fact that these studies are solely based on path dependence to analyse the evolution of tourism destinations is also the main limitation of existing tourism research. A critique of path

dependence – a concept that originally derived from evolutionary economics – and the need for further elaborations were the original focus of EEG (Martin & Sunley, 2006). The conception of path dependence in EEG evolved and progressed from a singular steady state approach based on equilibrist thinking drawn from economics to a continuous process perspective (Martin, 2010). Subsequently, the rethinking of path dependence in EEG led to the development of a broader range of path development literature. Path development includes 'positive path development', namely the drivers of new path development, as well as 'negative path development', namely the socioeconomic decline of regions. More fine-grained typologies of both positive and negative pathways have been developed. Whereas Grillitsch et al. (2018) identified six types of new path development, Blažek et al. (2020) highlighted three specific evolutionary paths of decline, namely the

Table 1. Types, mechanisms, and adaptation of the path development framework.

Path development trajectories	Mechanisms	Form of change at the industrial level Incremental // Radical
Downgrading	Removal of higher value-added functions, re-specialization in low-cost production.	Gradual foreign direct investment (FDI) inflows changing the structure of the industry. Gradual cutbacks or loss of skilled labour. // Sudden external changes, for example, the transformation of state-owned companies. Sudden cutbacks or loss of skilled labour.
Contraction	Reduction of product diversity /re-specialization. A withdrawal from some market segments and a gradual re-specialization of existing companies in a limited number of products, niches, or activities.	Gradual narrowing of the industrial scope through re-specialization. Lock-in due to overspecialization. Gradual cluster decline through a loss of skilled labour or accumulated staff cutbacks. // Sudden external changes in the demand of large multinational buyers. Sudden cluster decline through sudden staff cutbacks or mergers.
Delocalization	Relocation to more favourable locations.	Gradual reduction of investments leading to the displacement of higher value-added segments and the erosion of competitiveness. // Sudden shift of assets to another location leading to the dissolution of the regional industrial fabric.
Extension	Continuation of an existing industrial path based on incremental innovation in existing industries along well-established technological trajectories.	Gradual adaptation to slightly changing market conditions and technologies. Further growth of existing clusters. // No radical breaks.
Upgrading	1 Climbing the global production network 2 Renewal 3 Niche development	Gradual move towards various forms of upgrading among firms or clusters. Acquisition of new technologies. // Sudden upgrading after external shocks, through radical innovations, or through new business formation.
Importation	Setting up of an established industry that is new to the region and unrelated to existing industries in the region.	Gradual arrival of foreign companies and the inflow of skilled individuals with competences not available in the region. // Sudden investments by foreign companies with high-value-added functions
Branching	Diversification into a new related industry for the region, building on competencies and a knowledge of existing industries.	Gradual adaptation to changing market conditions and technologies. Gradual move towards new knowledge. // Establishment of products or processes through innovation or market entry through new business formation.
Diversification	Diversification into a new industry based on unrelated knowledge combinations.	Same as path branching.
Creation	Emergence and growth of entirely new industries based on radically new technologies and scientific discoveries or as an outcome of search processes for new business models, user-driven innovation, and social innovation.	Emergence of a cluster. // Emergence of new firms through new business formation. Establishment of new scientific, educational, or support infrastructure

Sources: Authors' elaboration drawing on Benner (2021), Blažek et al. (2020), Grillitsch et al. (2018).

downgrading, the concentration and the delocalization paths. However, many studies analysing the evolution of destinations never considered the recent, more fine-grained conceptualizations in the EEG field. Benner (2020) adapted the trajectories of path decline in the over-tourism context. Table 1 summarizes the nine different path development trajectories, along with their mechanisms, and the adaptation of the path development framework in tourism studies. The detailed typology of path development trajectories provides an innovative framework to understand how snowmaking development has influenced the ski tourism industry and with what effect.

This study focuses on two issues. Firstly, using a path development framework, it presents a better understanding of the evolution led by the spread of snowmaking in the French ski tourism industry. Secondly, the analysis of the development of technology in the ski tourism industry provides an opportunity to operationalize the conceptual framework of path development. Indeed, the current feedback on the practical operationalization of this theoretical framework to tourism case studies is limited.

Material and method

Study area

The study area is situated in the Savoie département (Savoie hereafter), in the Northern French Alps and the eastern part of France. According to the 'BD Stations' database (George-Marcelpoil et al., 2012), almost a third of the large and very large ski resorts in France ($n = 64$) are located in Savoie ($n = 20$). A third of the total ski lift power that French ski tourism offers is concentrated in the larger ski resorts of Savoie. Figure 1 illustrates the mean elevation and the ski lift power of Savoie's ski resorts and highlights the fact that Savoie has a large cable car portfolio. Private companies manage more than half of the large and very large ski resorts in Savoie. The Compagnie des Alpes – a large group listed on the stock exchange and one of the largest ski lift operators in the world (Falk, 2009) – manages six ski resorts in Savoie. From an economic viewpoint, a major part

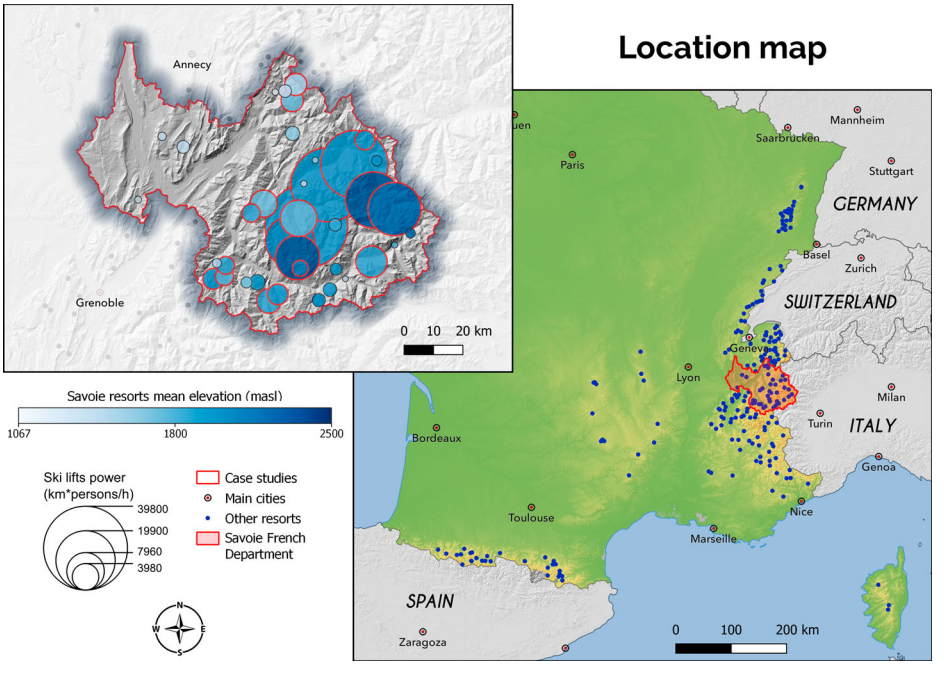

Figure 1. Maps of the study area.

of French ski tourism business is concentrated in Savoie. For the 2018/19 season, Savoie had a total of 21 million skier days, which accounted for an estimated 42% of all skier days in France (Montagne Leaders, 2019). Winter tourism prevails over other tourism activities, as it contributes to more than 75% of the nights spent in the region (Savoie-Mont-Blanc Tourisme, 2020). The average annual turnover of private ski lift companies in the 2004–2019 period was approximately EUR 19 million and in 2019 the turnover of private ski lift companies from Savoie represented 54% of the total turnover of private ski lift companies in the French Alps (Bureau van Dijk, 2019).

The first snowmaking system in the French Alps was introduced at Flaine (Haute-Savoie) in 1973 when the ski tourism industry still experienced the development of ski resorts (Knafou, 1978). Towards the end of the 1980s, snowmaking facilities required a sophisticated investment that only a handful of ski resorts could provide, many of them being from Savoie (Knafou, 1987). In the 1990s, snowmaking in the French Alps was still approached 'with extreme caution' being 'the last resort' (Vlès, 1996, p. 62). However, the proportion of equipped ski slopes increased towards the end of the 1990s and, more recently, still experiences dynamic growth (Spandre et al., 2015). Snowmaking is currently a powerful component of ski lift operations, being the second investment item for ski resorts in the French Alps (Berard-Chenu et al., 2020). In addition, over the 1997–2018 period, snowmaking investments in the ski resorts of Savoie represented 35% of the snowmaking investments made in all French ski resorts. Figure 2, indicating ski resort affiliations and investments made in snowmaking since 2000 regarding Savoie's ski resorts, shows that major French ski lift operators are deeply entrenched in Savoie.

With its well-established ski tourism industry, Savoie is characterized by a regional economy with a high degree of specialization. Therefore, its large ski resorts, with decade-long recurring and heavy investments in snowmaking, present an opportunity to understand how this technological innovation has influenced ski tourism path development.

Study design and research methods

We adopted a multi-method approach combining qualitative and quantitative research methods in this study. The data collection includes (i) documented information provided on the websites of ski resort companies, (ii) semi-structured interviews with ski tourism industry stakeholders, (iii) supplementary material transmitted through the interviews (i.e. technical documents, maps, marketing brochures, data tables), and (iv) key financial figures including investment datasets provided by the *Montagne Leaders* professional journal (Berard-Chenu et al., 2020).

We interviewed 38 stakeholders of the ski tourism industry, from October 2019 to November 2020. To design our study's sampling strategy, we first interviewed at least one person from the

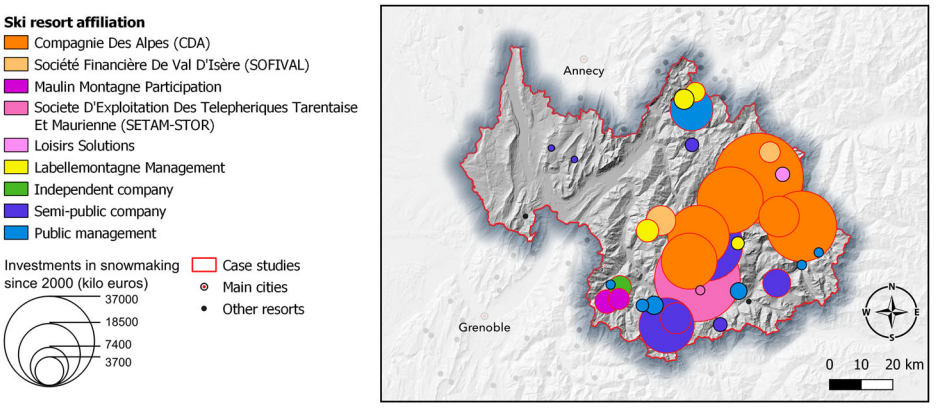

Figure 2. Affiliations and investments in snowmaking of Savoie's ski resorts since 2000.

ski lift operator company at each large ski resort in Savoie. Thereafter, we broadened the scope of the interviewed stakeholders using 'snowball sampling' (Merriam & Tisdell, 2016) – i.e. we interviewed stakeholders mentioned by interviewees. Relying on our first interviewees representing the ski resorts, we sometimes involved other employees of the ski lift operators (i.e. CEOs, chief operating officers, snowmaking managers). We also interviewed frequently mentioned stakeholders outside the ski lift companies such as ski resort developers or snowmaking providers. Depending on the ski resort and when mentioned by ski lift operators, we also consulted local politicians. Table 3 in the Appendix provides the detailed list of interviewees and their attributes. We subdivided these 38 interviewees into two groups: a core sample (CS) comprising ski lift stakeholders ($n = 30$) and an extended sample (ES) of eight more interviewees. In our extended sample, we included and interviewed three representatives of local authorities who were members of the National Association of Mayors of Mountain tourism villages (ANMSM). The ANMSM is an advocacy group consisting of mayors defending the interests of municipalities hosting ski resorts. Several times over the past years, this association has in defence challenged the use of snowmaking in the French ski tourism industry.

Pre-test interviews (i.e. a limited number of interviews with stakeholders to improve the questions and the interview method) were conducted to identify problematic, overly complex, or incomprehensible questions. After the pre-test interviews, we finalized and approved a semi-structured interview – rather than using a survey-based technique – that included a mix of more-structured and less-structured interview questions. Most of our data were collected through face-to-face interviews. Approximately 20% of interviews were online or phone interviews, due to the sanitary constraints of the COVID-19 crisis. In accordance with the interview guide, each interview followed the same pattern and included: (i) a description of the use of snowmaking and snowmaking management by the interviewee; (ii) a discussion of the role played by snowmaking in the ski tourism industry; and (iii) an indication of the evolution over time of snowmaking uses and their related causes [See Figure 6 in the Appendix]. To foster the discussion, we provided an overview of the snowmaking investments of the ski resort over the twenty past years to each core sample interviewee and invited each one to comment on it. Although the interview guide prescribed the same pattern for each interview, we adjusted the asked questions between our core and extended samples. The interviews were recorded and transcribed. Audio tracks and written transcriptions were analysed using Nvivo, a qualitative data analysis software (Bazeley, 2013; Woolf & Silver, 2017). We included two coding cycles in the data analysis process. The first, referred to as Descriptive Coding, was implemented to summarize segments of data and the second, called Pattern Coding, was used to identify themes, configurations or explanations (Miles, 2013; Saldaña, 2015). Regarding the key financial figures of the ski tourism industry, we conducted a systematic review of snowmaking investments in the 20 largest ski resorts of Savoie, covering the 1997–2018 period. We also used the Diane database obtained from Bureau van Dijk (2019) to conduct an overview of the French snowmaking market. We furthermore collected and summarized accounting information covering the 2012–2019 period, obtained from four snowmaking providers.

Results

Our analysis of snowmaking development from an evolutionary perspective produced three important results. Firstly, snowmaking induces changes at both ski lift and ski resort levels. Progress made in snowmaking technology has encouraged its adoption by ski lift operators, coupled with an organizational change in ski lift management. Secondly, the incentive for snowmaking is strongly associated with the specialization strategies adopted by ski lift operators. Thirdly, the characteristics of the development of snowmaking reveal a trajectory between path extension and path contraction in the ski tourism industry.

Snowmaking as a technological and an organizational innovation for ski lift operations

Technical progress from the late 1980s to the early 2000s has favoured the spread of snowmaking technology. Although not a 'shock' with a well-defined beginning and end, the trend nevertheless initiated substantial change. According to a research and development director of a snowmaking company (#37), automated systems – technical progress arising during the late 1980s – were a prerequisite for the emergence of the snowmaking market in Western Europe. Automated systems offered two advantages that eased snowmaking use on the European market. Firstly, automated systems were attractive as they took advantage of shorter weather windows. While snowmaking was initially developed in North America under the influence of a continental climate, snowmakers in Western Europe had to contend with a more temperate climate. Secondly, automated systems also decreased labour costs. In addition to automated systems, the technical progress increased the yield that made snowmaking more efficient. Interviewees were unanimous about the technical progress made by snowmaking suppliers over the past 20 years. The snowmaking market in France experienced an historical turning point in the late 1990s and early 2000s. The higher level of efficiency in snow production had a strong effect on snowmaking development, as confirmed by a mayor of a ski resort (#3): 'From 1989 to now, the efficiency of snow guns has been multiplied by 15 or 16. That means that with the energy required for one snow gun in 1989, we can (now) run 15: we made a revolutionary step to increase the production'.

Snowmaking systems have modified the seasonal or multi-year term management of ski areas. The creation of highly specialized knowledge and the increase in snowmaking-related investments were the two major evolutions that reflected the growing entrenchment of the ski tourism industry in technological dependence. Snowmaking absorbs a share of the investment abilities of ski lift operators that contributes to specialized capital accumulation, including human capital. The specialized knowledge required for snowmaking incorporated the setting up of processes, the use of more advanced tools, and the training of qualified workers. Ski lift operators have also developed structured working routines to manage snowmaking systems, and have formalized their established know-how by implementing professional certification in 2018. The implementation of these indicators has been accompanied by the extensive use of measuring devices related to snowmaking management: water and power consumption measurements, snow depth measurements, the high-resolution mapping of ski slopes, meteorological and climate prediction, and snow management systems (e.g. the H2020 project PROSNOW, see Köberl et al., 2021). This mix of dedicated decision-making tools that aid snowmaking management has not only improved the efficiency of snowmaking but has also promoted its use. As a result, snowmaking management migrated from an experience-based approach to a more process-based approach, and snowmaking ability has emerged as an advanced and specific function of ski lift management.

Common standards in snowmaking management drive the development of the snowmaking network and future investments. Several interviewees mentioned that snowmaking facilities were planned along with multi-year investment plans and were deeply intertwined with other ski lift investments. As mentioned by a marketing director of a snowmaking company (#38): 'Nowadays, it is quite inconceivable to plan a new ski lift without being able to guarantee the skiing experience associated with that ski lift'. A CEO of a ski lift company (#13) also claimed: 'We do not only work on ski lifts anymore, we think in terms of ski-area sectors: the ski lift is only the means of transportation, we also work on ski slopes and snowmaking'. Figure 3 depicts the evolution of snowmaking-related investments, covering the 1997–2018 period, for the 20 largest ski resorts of Savoie that we investigated. It shows that the set of investments linked to snowmaking has increased over time. At the beginning of the 2000s, snow guns represented 80% of the snowmaking investments made by the surveyed ski resorts; fifteen years later these investments only accounted for half of all the investments made. Civil engineering to build more powerful engine rooms and water reservoirs to ensure

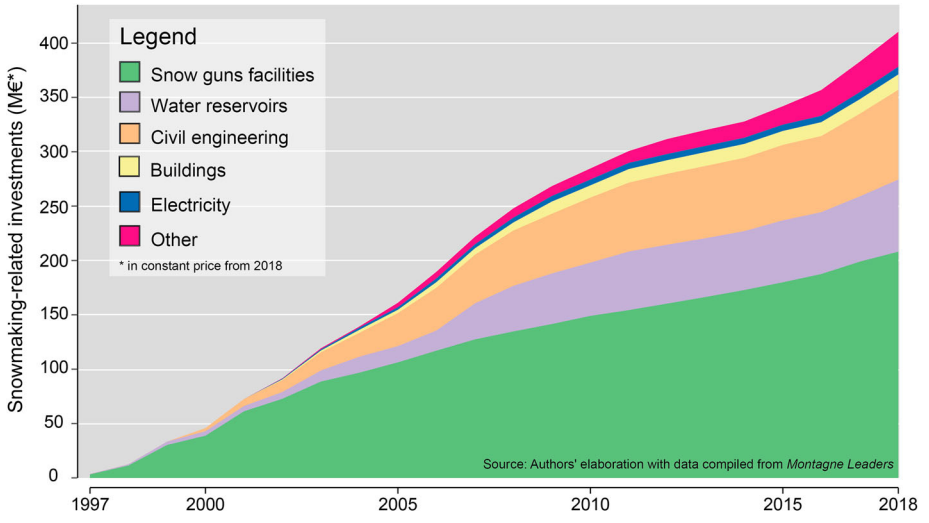

Figure 3. Evolution of snowmaking-related investments in Savoie's 20 largest ski resorts, for the 1997–2018 period.

the water supply management absorbed 40% of the total amount of investment. Snowmaking has therefore induced its own investment regime (e.g. civil engineering or water reservoir facilities), while dated equipment also requires maintenance investments. These investments increase the snowmaking assets of ski resorts.

Snowmaking as a sign of the 'specialization turn' of ski lift operators

Snowmaking development started after the era characterized by the development of ski resorts. The late-1980s crisis involving the bankruptcy of several real estate and ski resort developers marked the end of the ski resorts' development era. Considering that the French ski market had reached maturity, the development of new ski resorts and the extension of ski areas were no longer relevant. As a result, the central stakeholder who developed the ski resort and monitored all the activities related to skiing gave way to mono-activity actors, who focused only on one activity within the ski resort. The iconic focusing strategy was exemplified by the launch of the Compagnie des Alpes in 1989; a firm specializing in ski lift operations. The Compagnie des Alpes made a business acquisition of several ski resorts as subsidiaries: from 1989 to 1999 the company acquired seven ski lift operators and another five over the 2000–2010 period. Its strategy was to focus only on the management of ski lift operations and not to be involved in real estate development, in ski schools or in other ski-related activities. The specialization of ski lift operators – focusing on their core business by, amongst others, abandoning certain activities like real estate development or activities in the supply chain of ski tourism – prompted them to guarantee snow reliability. In this context, snowmaking emerged as an extension of progressive experimental innovation at different ski resorts that was eventually widely adopted.

The increasing use of snowmaking also fostered the development of a dedicated market that displays the characteristics of a quasi-monopolistic market. Regarding the evolution of snowmaking providers in Europe, we also saw the same process of concentration that Mayer (2009) observed with reference to ski lift providers. We identified at least eight independent snowmaking providers in the period before 2000. After the concentration of national markets, the same process occurred at a European level in the early 2010s. In 2012, the Italian company TechnoAlpin took over Johnson Controls Neige, its main challenger in France. At the same time, the MND group merged with an Italian, a Swedish, and an Austrian company, respectively in 2011 and 2013.

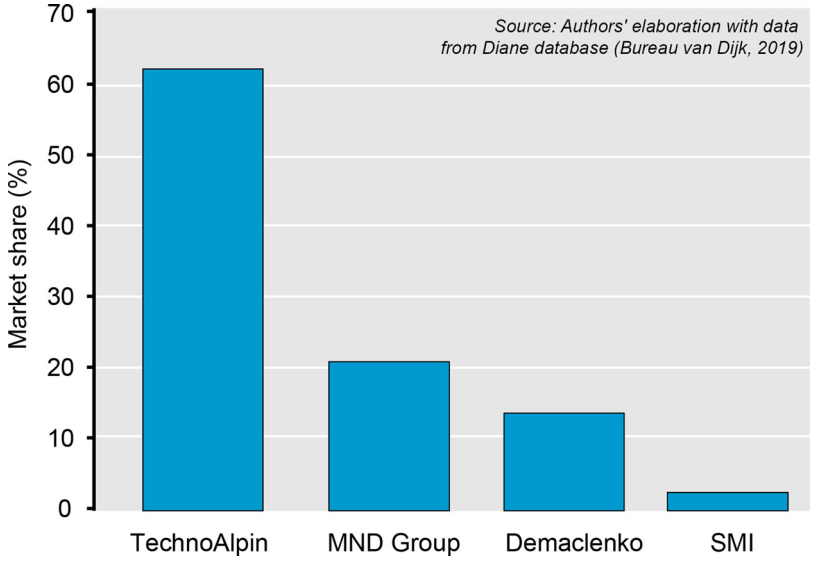

Figure 4. French market share of leading snowmaking companies (based on a yearly average over the 2013–2019 period).

Regarding turnovers of major snowmaking companies operating in the French market over the 2012–2019 period, we estimated the snowmaking market to be worth about EUR 35 million per year. Figure 4 displays the distribution of market shares in the French snowmaking sector per yearly average over the period 2013–2019**.** It shows that the market-leader company held a market share of more than 60%. Ski lift operators clearly confirmed their dependence on a specific snowmaking provider. Because the supervision system and equipment are both specific to each provider, ski lift operators mentioned the lack of interoperability between snowmaking systems and their feeling of being locked into their initial choices. Considering the full automation of snowmaking systems, ski lift operators said that their providers have made them captive of their technology. This lack of competition induced price increases, leaving little margin for trade negotiations. Finally, the absence of alternatives also enhanced the adoption of recommendations made by the snowmaking providers.

The interviews furthermore revealed that, in conjunction with the specialization of ski lift operators, other stakeholders in the ski tourism industry also drove snowmaking development. In the business-to-business situation of the ski tourism industry, snowmaking became a negotiation issue as ski lift operators promoted the fraction of their ski slopes covered with snowmaking as a commercial advantage. As a ski lift company's CEO explained (#27): 'Snowmaking as a commercial advantage has also been promoted by tour operators … Since they were simultaneously present in many different ski resorts at the same time, they were able to compare what ski resort operators could offer'. Ski lift operators want to attract tour operators as they ensure the purchase of a batch of ski lift tickets months before the opening of the ski season. Since tour operators give an advance assurance of skier traffic at ski resorts, snowmaking provides a guarantee to both ski lift operators and tour operators. Snowmaking is also well-integrated into the real estate development of large ski resorts. Many interviewees, from both the core and extended samples, mentioned snowmaking as a key component of accommodation marketing offering ski-in/ski-out packages. Considering that altitude is no longer a sufficient criterion to justify ski-in/ski-out practices, tour operators and real estate developers request investments in snowmaking facilities at ski resorts. Interviewed tour operators and real estate developers indicated that snowmaking was a way to reassure their investors. A chief operating officer from a major European real estate development company (#4), partly specializing in ski tourism accommodation, mentioned that 'ski-in/ski-out accommodation is still a sought-

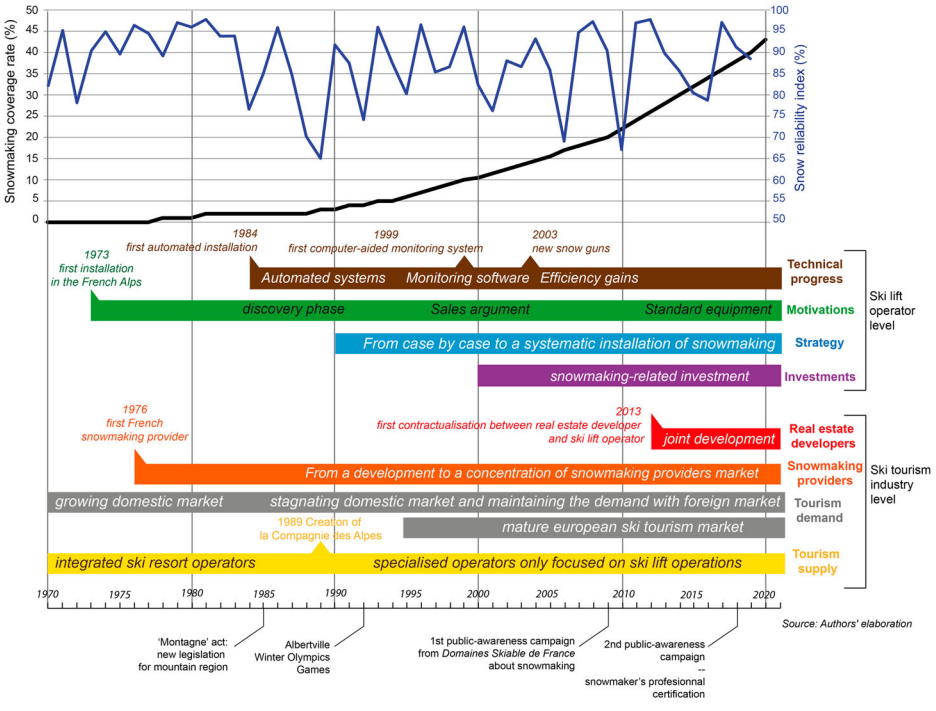

Figure 5. Schematic presentation of the snowmaking development and evolution of the French ski tourism industry.

after product' and, in respect of any new real estate projects, requested ski slopes covered with snowmaking from ski lift operators. A manager from an international company specializing in all-inclusive holidays (#5) also mentioned that 'snowmaking facilities on the ski slopes leading to our resort are part of things that we discussed [with the ski lift operator and the local community]'. Snowmaking investments linked to the development of accommodation were often contracted in a three-party agreement signed between the ski lift operator, the local authority (e.g. the municipality), and the tour operator. For instance, as a mayor (#2) explained: 'Snowmaking is not even a negotiating point. It is obvious that a local authority which deals with potential investors shall guarantee ski-in/ski-out access'. Some respondents also mentioned the recent trend in the way ski resort stakeholders regard snowmaking. A CEO of a ski lift company (#19) claimed: 'We already have some hotelkeepers who paid to be sure to have some snow in front of their accommodation, because it provides an added value to their products. They paid for their snow guns'. Given the increasing numbers of stakeholders that have integrated snowmaking into their businesses, snowmaking systems went well beyond the adjunctive technology that was only considered by ski lift operators for their operations. These results highlight that the diffusion of snowmaking has been embarked upon by all stakeholders of the ski tourism industry. Figure 5 provides a schematic overview of the development of snowmaking, from 1970 to 2020, in the French ski tourism industry. The top half of the figure shows two trends: the evolution of the snow reliability index (Spandre et al., 2019) depicting the inter-annual variability of snow conditions, depending on natural snowfalls, and the steady increase of the share of the ski slope covered by snowmaking. The bottom half of the figure summarizes several evolutions described by our interviewees. It not only illustrates the evolution of snowmaking technology along with its major technical progress, but also its increasing systematic use. The figure also shows the evolution of the snowmaking market and the main changes observed in the French ski tourism market, including the specialization of ski lift operators who invest in ski lift management as their main business.

Table 2. Path extension and path contraction due to the development of snowmaking in the ski tourism industry.

Path development trajectories	Ski tourism industry and drivers of the snowmaking development	Key dimension
Extension	The gradual development of snowmaking technology, sometimes aided by single events like snow-scarce seasons or by incremental changes such as technical progress. The willingness of French ski lift operators to upgrade their snowmaking equipment to the level of their European competitors. New range of investments.	Development of specific investments to increase resilience against natural snow cover variability. Development of specialized assets. Strengthen the position of ski lift operators in a competitive market and climate change context.
Contraction	Snowmaking development follows the specialization of the French ski tourism industry at the end of the 1980s. Ski lift operators only focus on ski lift operations and abandon other tourism-related activities (e.g. real estate development and ski schools) The snowmaking providers market enters a merger phase. High pace of snowmaking investments.	Increasing capital accumulation related to the need to upgrade existing assets (e.g. snow guns, monitoring systems, tool-related snowmaking). Increasing dependence of ski lift operators on snowmaking providers due to mergers. Declining range of competencies at the firm level.

Source: Authors' elaboration.

A ski tourism industry between path extension and path contraction trajectories

When we relate the findings based on our data collection and analysis with the theoretical framework of path development, we notice that the deployment of snowmaking fits the mechanisms involved in two different path development trajectories. Table 2 summarizes insights garnered from our study, combined with the theoretical framework of path development. During its early stage, snowmaking development conformed to a path extension process in the ski tourism industry. Snowmaking supported ski lift operators' strategy to move away from only ski lift operations towards the management of ski areas, i.e. to simultaneously guarantee skiers transportation with ski lifts and a downhill skiing experience. This evolution was emblematically illustrated in 2010 by the renaming of the professional association of the French ski lift operators, switching from the 'French Cable Car Association' (*Syndicat National des Téléphériques de France*) to the 'French Ski Areas Association' (*Domaines Skiables de France*).

Snowmaking guarantees an existing ski tourism industry along a well-established technological trajectory. This specialization has been enforced over time and has been helped along by the incremental innovations made by snowmaking providers. Ski lift operators initially used snowmaking as a complementary technology to ensure snow reliability and to compensate for the lack of snow in case of insufficient snowfall amounts. Initially used only on specific occasions, snow production has progressively become a standard, being used every winter.

We also link the development of snowmaking to a path contraction trajectory of the ski tourism industry. The development of snowmaking followed a specialization strategy that is reflected in the reduction of the portfolio of activities performed by ski lift operators. Snowmaking is a specific investment that has been supporting the specialization strategy since it has no other purpose than to guarantee downhill skiing. Observed mergers between snowmaking providers over past years are evidence that the snowmaking market has entered a maturity phase. Finally, our study shows that the line between path extension and path contraction is blurred. While we point out that snowmaking initially appeared as a path extension of the management of ski resorts, we also emphasized that with the passing of time as investments in this technology increased, the path development trajectory approached that of path contraction.

Discussion

Our study, based on 38 in-depth interviews and key financial figures, enabled us to provide a broad picture of snowmaking dynamics. Snowmaking, both as a technological innovation and as an

organizational innovation, deeply modified ski resort management and eventually spread to many stakeholders of the ski tourism industry. Building on the path development framework, we linked the deployment of snowmaking to both path extension and path contraction. Our results clearly show that this technology, being related to two path developments, had an ambivalent impact on the ski tourism industry. Future possibilities differ depending on the considered path. Path extension allows the rejuvenation of the regional economy based on the use of existing knowledge and assets, while path contraction displays a more negative perspective.

In the case of path extension, an increase is expected in competitiveness against both national and international competitors on the ski tourism market. The interviewed ski lift operators claimed that they were less equipped with snowmaking systems than their European competitors, especially the Austrian and the Italian ski resorts. They furthermore believed that investments in snowmaking were essential to ensure their competitiveness. We suggest that snowmaking has enabled large ski resorts to keep to a well-established development trajectory, which likely explains the long-standing success of the ski tourism industry in Savoie. Snowmaking has also spurred the development of a market niche for highly specialized firms, amongst others for the providers of snowmaking tools.

In the case of path contraction, the over-specialized investments of ski lift operators could have a negative effect on new path development opportunities. For instance, in a climate change context, over-specialized assets can lead to the risk of maladaptation (Schipper, 2020; Scott et al., 2022) as a committed adaptation capacity has for decades not increased the resilience of the ski tourism industry. The overspecialization of ski lift operators can diminish opportunities to start new path developments such as diversification or path branching. Snowmaking facilities damage mountainous environments by affecting landscapes and natural resources (Casagrande Bacchiocchi et al., 2019) and can also induce negative environmental perceptions amongst tourists (Bausch et al., 2019). Although snowmaking is somewhere in a continuum from successful adaptation to maladaptation (Scott et al., 2022), intensive snowmaking development may launch a downgrading path, i.e. the loss of high-value characteristics previously benefiting ski tourism and non-ski activities.

Although path extension and path contraction seem to be two contradictory path developments, a gradual switch from the one to the other appears possible. Considering that path extension relies primarily on continuity and existing knowledge, Isaksen and Trippl (2016) stressed that a limited innovation potential may lead to stagnation and the end of this path. In the case of path contraction, and despite a decrease in capital accumulation, Blažek et al. (2020) admitted that this path can lead to new investments with short-term regional benefits. Therefore, the termination of path extension can easily continue with the opening of path contraction. Our case study clearly illustrated that the effects of an ongoing strategy of snowmaking deployment in the ski tourism industry evolve into the risk of turning a positive lock-in into a negative lock-in. The ambivalent situation brought about by snowmaking developments, oscillating between costs and benefits, is acknowledged by the CEO of a ski lift company (#19) who categorically stated: 'Snowmaking is a necessary evil. I say 'evil' because it is expensive and if we could do without it, we would do without it. But we cannot do without it anymore, this is no longer possible. It is necessary; it is like a seatbelt to avoid crashes.' Blažek et al. (2020) also show that path contraction can have ambivalent effects on the level of resilience. Regarding snowmaking, it can reduce the climate vulnerability of ski resorts by increasing their snow reliability index, especially when contending with challenging snow conditions. Ski lift operators with a higher snowmaking coverage might be more resilient to the impact of natural snow cover variability than their competitors. However, warmer temperatures or a major crisis, such as the COVID-19 pandemic that led to the closure of French ski resorts for the 2020/2021 season, can reduce any strategy relying on snowmaking to futility.

We assume that the development of snowmaking can be seen as a long-term process that shifts between different sequences of path development (Benner, 2022). However, it remains difficult to determine the tipping point between one path and another, especially considering the lack of empirical studies that apply the same framework to different periods of development. Therefore,

it would be interesting to apply the path development framework to analyse different ski tourism markets such as the booming market in China (Zhe et al., 2022) or ski resort closures as in North America (Moscovici, 2022), as this framework would provide a better understanding of ski tourism industry trajectories by, for example, including a comparative analysis of empirical studies.

In this study, we showed that the mechanisms of snowmaking development rely on all supply-side stakeholders of the ski tourism industry, including local authorities. The common vision of snowmaking development evident amongst the interviewees of our core sample and the local politicians included in our extended sample reveals the strong ties that bind ski lift operators and public authorities. We suggest that 'political' lock-ins (Boschma & Lambooy, 1999; Grabher, 1993; Hassink, 2005) – i.e. thick institutional ties that aim to preserve existing traditional industrial structures – most likely exist and contribute to the shaping of path development trajectories. We also assume that institutions can have an ambivalent effect on the evolution of the ski tourism industry, either by reinforcing an existing path, for example by rolling out a pro-snowmaking policy (Berard-Chenu et al., 2022), or by enhancing other trajectories such as diversification programs.

Conclusion

Our study underlines an interest and the importance of a path development approach to explain the poorly known mechanisms and dynamics of snowmaking in the French ski tourism industry. If, from an ecological and a social perspective, snowmaking raises matters which still need to be assessed in depth, our study shows that the overall assessment of the evolution of the ski tourism industry allows a better understanding of past and ongoing snowmaking development. Both the positive and negative effects of path extension and of path contraction related to snowmaking shed light on the challenges confronting the ski tourism industry and on the ability of its stakeholders to go beyond technological adaptation in a climate change context.

This perspective on the development trajectory of the ski tourism industry has certain limitations. The sophistication of the theoretical framework of path development requires further implementation, including its application to various tourism case studies. Path development trajectories are archetypal and finding an empirical situation that perfectly fits the mechanisms of one of these archetypes is unlikely, especially if case studies refer to recent phenomena which are still ongoing. Rather than a clear affiliation with one path, it seems that there are some intervals or levels leading from one path to another, in a non-linear scheme.

Another limitation of our study relates the geographical area and ski resorts under consideration. Since we considered only the categories of large and very large ski resorts, we did not address the situation of smaller ski resorts, which presents distinct characteristics. Often located at a lower altitude and having less financial and engineering resources to invest than larger ski resorts, including investments in snowmaking facilities, small ski resorts appear to occupy a marginal position in the ski tourism industry. A comparative analysis between small and large ski resorts could reveal different path development trajectories. Since our study only focuses on the industrial aspect of the development of snowmaking, a coevolution analysis (Benner, 2021) integrating the role of institutions in the development of the tourism economy at the regional level would be relevant. The role of public authorities and regulations are even more crucial in France where ski lift operators only lease and use ski lifts while municipalities keep ownership over ski lift facilities when the lease is terminated. Thus, a detailed analysis of institutional practices could shed light on both regulatory and policy systems that shape the evolution of snowmaking in the ski tourism industry.

Further research on mountainous regional economies needs to disentangle the purposes served by these firms, which focus on short-term or mid-term profitability and the local communities' goals. On the one hand, firms from the ski tourism industry can quickly reallocate their assets, connect with other actors outside the region and initiate new path development beyond their native region. On the other hand, local communities or ski destinations might be less responsive, having a deeper local anchorage than firms. In the latter case, the short-term choices of ski lift operators may have

economic benefits from a business perspective, but these choices may also constrain the evolution of the path development of mountainous regions. Since the initiation of new path developments is unlikely to happen if it only relies on endogenous changes of the ski tourism industry, the remaining challenge is to unlock mountainous regions while, in a complementary manner, also addressing the need to devise alternative and more sustainable development paths for mountain societies.

Acknowledgement

We thank the two anonymous reviewers for their constructive comments and suggestions to revise the original version of this paper. LBC, SM, HF and EG designed the research; LBC collected and analysed the data with the support of the co-authors; LBC and HF produced the figures with the support of the co-authors; all authors contributed to the analysis and interpretation of the results; LBC authored the paper, using feedback received from all co-authors. A part of this paper is derived from a chapter of the thesis of Lucas Berard-Chenu, *Evolutionary trajectories of ski resorts in the French Alps: The place of snowmaking*.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Agence Nationale de la Recherche [grant number ANR-15-IDEX-02]; Horizon 2020 [grant number 730203].

ORCID

Lucas Berard-Chenu http://orcid.org/0000-0002-9629-3826
Hugues François http://orcid.org/0000-0002-9976-7687
Samuel Morin http://orcid.org/0000-0002-1781-687X
Emmanuelle George http://orcid.org/0000-0002-0802-2605

References

Abegg, B., Agrawala, S., Crick, F., & Montfalcon, A. (2007). *Climate change in the European Alps: Adapting winter tourism and natural hazards management*. https://www.oecd.org/env/cc/climatechangeintheeuropeanalpsadaptingwintertourismandnaturalhazardsmanagement.htm

Abegg, B., Steiger, R., & Trawöger, L. (2017). Resilience and perceptions of problems in alpine regions. In R. W. Butler (Ed.), *Tourism and resilience* (pp. 105–117). Cabi. https://doi.org/10.1079/9781780648330.0105.

Bausch, T., Humpe, A., & Gössling, S. (2019). Does climate change influence guest loyalty at alpine winter destinations? *Sustainability*, *11*(15), 4233. https://doi.org/10.3390/su11154233

Bazeley, P. (2013). *Qualitative data analysis with NVivo* (2nd ed.). SAGE Publications Ltd.

Benner, M. (2020). The decline of tourist destinations : An evolutionary perspective on overtourism. *Sustainability*, *12*(9), 3653. https://doi.org/10.3390/su12093653

Benner, M. (2021). Retheorizing industrial–institutional coevolution : A multidimensional perspective. *Regional Studies*, *0*(0), 1–14. https://doi.org/10.1080/00343404.2021.1949441

Benner, M. (2022). Revisiting path-as-process : agency in a discontinuity-development model. *European Planning Studies*, *0*(0), 1–20. https://doi.org/10.1080/09654313.2022.2061309

Berard-Chenu, L., Cognard, J., François, H., Morin, S., & George, E. (2020). Do changes in snow conditions have an impact on snowmaking investments in French Alps ski resorts? *International Journal of Biometeorology*. https://doi.org/10.1007/s00484-020-01933-w

Berard-Chenu, L., François, H., George, E., & Morin, S. (2022). Snowmaking development trajectories in French alpine Ski resorts : The influence of local specificities and regional support policies. *Journal of Alpine Research | Revue de Géographie Alpine*, *4*, Art. 4. https://doi.org/10.4000/rga.10465

Berard-Chenu, Lucas. (2021). *Evolutionary trajectories of ski resorts in the French Alps: The place of snowmaking* (Thesis, Université Grenoble Alpes) https://tel.archives-ouvertes.fr/tel-03555501.

Bicknell, S., & Mcmanus, P. (2006). The canary in the coalmine : Australian Ski resorts and their response to climate change. *Geographical Research*, *44*(4), 386–400. https://doi.org/10.1111/j.1745-5871.2006.00409.x

Blažek, J., Květoň, V., Baumgartinger-Seiringer, S., & Trippl, M. (2020). The dark side of regional industrial path development : towards a typology of trajectories of decline. *European Planning Studies*, *28*(8), 1455–1473. https://doi.org/10.1080/09654313.2019.1685466

Boschma, R., & Frenken, K. (2006). Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography*, *6*(3), 273–302. https://doi.org/10.1093/jeg/lbi022

Boschma, R., & Lambooy, J. (1999). The prospects of an adjustment policy based on collective learning in old industrial regions. *GeoJournal*, *49*(4), 391–399. https://doi.org/10.1023/A:1007144414006

Brouder, P., Clavé, S. A., Gill, A., Ioannides, D., Clavé, S. A., Gill, A., & Ioannides, D. (2016). *Tourism destination evolution*. *Routledge*. https://doi.org/10.4324/9781315550749

Brouder, P., & Eriksson, R. H. (2013). Tourism evolution : On the synergies of tourism studies and evolutionary economic geography. *Annals of Tourism Research*, *43*, 370–389. https://doi.org/10.1016/j.annals.2013.07.001

Bureau van Dijk. (2019). *Diane database*. https://www.bvdinfo.com/en-gb/our-products/data/national/diane

Butler, R. W. (1980). The concept of a tourist area cycle of evolution : implications for management of resources. *The Canadian Geographer/Le Géographe Canadien*, *24*(1), 5–12. https://doi.org/10.1111/j.1541-0064.1980.tb00970.x

Campos Rodrigues, L., Freire-González, J., González Puig, A., & Puig-Ventosa, I. (2018). Climate change adaptation of alpine Ski tourism in Spain. *Climate*, *6*(2), 29. https://doi.org/10.3390/cli6020029

Casagrande Bacchiocchi, S., Zerbe, S., Cavieres, L. A., & Wellstein, C. (2019). Impact of ski piste management on mountain grassland ecosystems in the Southern Alps. *Science of The Total Environment*, *665*, 959–967. https://doi.org/10.1016/j.scitotenv.2019.02.086

DSF. (2020). *Indicateurs et analyses* 2020. Domaines Skiables de France. https://www.domaines-skiables.fr/smedia/filer_private/41/d2/41d2abea-3518-4199-a0bf-69539fea06ea/indicateurs-et-analyses-2020.pdf

Falk, M. (2009). Are multi-resort ski conglomerates more efficient? *Managerial and Decision Economics*, *30*(8), 529–538. https://doi.org/10.1002/mde.1470

Falk, M., & Lin, X. (2018). The declining dependence of ski lift operators on natural snow conditions. *Tourism Economics*, 1354816618768321. https://doi.org/10.1177/1354816618768321

Falk, M., & Vanat, L. (2016). Gains from investments in snowmaking facilities. *Ecological Economics*, *130*, 339–349. https://doi.org/10.1016/j.ecolecon.2016.08.003

George-Marcelpoil, E., François, H., Fablet, G., Bray, F., Achin, C., Torre, A., & Barré, J. B. (2012). *Atlas des stations du massif des Alpes* [François]. http://www.observatoire-stations.fr/to_download/atlas_alpes_nov2012_version-web.pdf

Gill, A. M., & Williams, P. W. (2014). Mindful deviation in creating a governance path towards sustainability in resort destinations. *Tourism Geographies*, *16*(4), 546–562. https://doi.org/10.1080/14616688.2014.925964

Gill, A. M., & Williams, P. W. (2016). Contested pathways towards tourism-destination sustainability in whistler, British Columbia. In P. Brouder, S. A. Clavé, A. Gill, & D. Ioannides (Eds.), *Tourism destination evolution* (p. 43). Routledge.

Gonseth, C. (2008). *Adapting ski area operations to a warmer climate in the Swiss Alps through snowmaking investments and efficiency improvements*. Ecole Polytechnique Fédérale de Lausanne. https://infoscience.epfl.ch/record/124842

Grabher, G. (1993). The weakness of strong ties ; The lock-in of regional development in Ruhr area. In *The embedded firm ; On the socioeconomics of industrial networks* (pp. 255–277). Routledge. https://ci.nii.ac.jp/naid/10030364606/

Grillitsch, M., Asheim, B., & Trippl, M. (2018). Unrelated knowledge combinations : The unexplored potential for regional industrial path development. *Cambridge Journal of Regions, Economy and Society*, *11*(2), 257–274. https://doi.org/10.1093/cjres/rsy012

Hassink, R. (2005). How to unlock regional economies from path dependency? From learning region to learning cluster. *European Planning Studies*, *13*(4), 521–535. https://doi.org/10.1080/09654310500107134

Hjalager, A.-M. (2015). 100 innovations that transformed tourism. *Journal of Travel Research*, *54*(1), 3–21. https://doi.org/10.1177/0047287513516390

Hock, R., Rasul, G., Adler, C., Cáceres, B., Gruber, S., Hirabayashi, Y., Jackson, M., Kääb, A., Kang, S., Kutuzov, S., Milner, A., Molau, U., Morin, S., Orlove, B., Steltzer, H., Allen, S., Arenson, L., Baneerjee, S., Barr, I., … Zhang, Y. (2019). *High mountain areas* (pp. 131–202). IPCC – Intergovernmental Panel on Climate Change. http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-414230

Isaksen, A., & Trippl, M. (2016). 4 path development in different regional innovation systems : A conceptual analysis. In D. Parrilli, R. Dahl Fitjar, & A. Rodriguez-Pose (Eds.), *Innovation drivers and regional innovation strategies* (pp. 82–100). Routledge. https://doi.org/10.4324/9781315671475-12

Knafou, R. (1978). *Les stations intégrées de sports d'hiver des alpes françaises : l'aménagement de la montagne à la « française »*. Masson.

Knafou, R. (1987). L'évolution récente de l'économie des sports d'hiver et de l'aménagement touristique de la montagne en France. *Revue de Géographie Alpine*, *75*(2), 101–114. https://doi.org/10.3406/rga.1987.2671

Köberl, J., François, H., Cognard, J., Carmagnola, C., Prettenthaler, F., Damm, A., & Morin, S. (2021). The demand side of climate services for real-time snow management in alpine ski resorts : some empirical insights and implications for climate services development. *Climate Services*, *22*, 100238. https://doi.org/10.1016/j.cliser.2021.100238

Ma, M., & Hassink, R. (2013). An evolutionary perspective on tourism area development. *Annals of Tourism Research*, *41*, 89–109. https://doi.org/10.1016/j.annals.2012.12.004

Martin, R. (2010). Roepke lecture in economic geography—rethinking regional path dependence : beyond lock-in to evolution. *Economic Geography*, *86*(1), 1–27. https://doi.org/10.1111/j.1944-8287.2009.01056.x

Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Geography*, *6*(4), 395–437. https://doi.org/10.1093/jeg/lbl012

Mayer, M. (2009). Innovation as a success factor in tourism : empirical evidence from western Austrian cable-Car companies. *Erdkunde*, *63*(2), 123–139. https://doi.org/10.3112/erdkunde.2009.02.02

Mayer, M., Steiger, R., & Trawöger, L. (2007). Technischer schnee rieselt vom touristischen machbarkeitshimmel – schneesicherheit und technische beschneiung in westösterreichischen skidestinationen vor dem hintergrund klimatischer wandlungsprozesse. *Mitteilungen der Österreichischen Geographischen Gesellschaft*, *149*, 157–180. https://www.uibk.ac.at/geographie/personal/steiger/abstract_moegg.pdf

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research : A guide to design and implementation* (4th ed.). Jossey-Bass, a Wiley Brand.

Miles, M. B. (2013). *Qualitative data analysis : A methods sourcebook [electronic resource]* (3rd ed.). SAGE Publications, Inc.

Montagne Leaders. (2019). *Enquête Top 100*—2019. https://www.montagneleaders.fr/enquetes/top-100/enquete-top-100-2019/

Morrison, C., & Pickering, C. M. (2013). Perceptions of climate change impacts, adaptation and limits to adaption in the Australian Alps : The ski-tourism industry and key stakeholders. *Journal of Sustainable Tourism*, *21*(2), 173–191. https://doi.org/10.1080/09669582.2012.681789

Moscovici, D. (2022). Ski resort closures and opportunities for sustainability in North America. *Land*, *11*(4), 494. https://doi.org/10.3390/land11040494

Müller, D. K. (2019). An evolutionary economic geography perspective on tourism development in a remote Ski resort : The case of Tarnaby/Hemavan in the Swedish mountains. In R. L. Koster & D. A. Carson (Eds.), *Perspectives on rural tourism geographies : case studies from developed nations on the exotic, the fringe and the boring bits in between* (pp. 137–157). Springer International Publishing. https://doi.org/10.1007/978-3-030-11950-8_8

Paccard, P. (2010). *Gestion durable de l'eau en montagne : Le cas de la production de neige en stations de sports d'hiver*. [Thèse de doctorat], Université de Savoie. https://tel.archives-ouvertes.fr/tel-00572604/document

Papatheodorou, A. (2004). Exploring the evolution of tourism resorts. *Annals of Tourism Research*, *31*(1), 219–237. https://doi.org/10.1016/j.annals.2003.10.004

Saldaña, J. (2015). *The coding manual for qualitative researchers [electronic resource]* (3rd ed.). SAGE.

Sanz-Ibáñez, C., & Clavé, S. A. (2014). The evolution of destinations : towards an evolutionary and relational economic geography approach. *Tourism Geographies*, *16*(4), 563–579. https://doi.org/10.1080/14616688.2014.925965

Savoie-Mont-Blanc Tourisme. (2020). *Les chiffres clés* (p. 72). Observatoire du tourisme Savoie-Mont-Blanc Tourisme. https://pro.savoie-mont-blanc.com/var/ezwebin_site/storage/original/application/75f9465d8cb7c4462bfdb00d4d6ce1aa.pdf

Schipper, E. L. F. (2020). Maladaptation : when adaptation to climate change goes very wrong. *One Earth*, *3*(4), 409–414. https://doi.org/10.1016/j.oneear.2020.09.014

Scott, Daniel, Knowles, Natalie, & Steiger, Robert. (2022). Is snowmaking climate change maladaptation?. *Journal of Sustainable Tourism*, 1–22. http://dx.doi.org/10.1080/09669582.2022.2137729

Spandre, P., François, H., George-Marcelpoil, E., & Morin, S. (2016). Panel based assessment of snow management operations in French ski resorts. *Journal of Outdoor Recreation and Tourism*, *16*, 24–36. https://doi.org/10.1016/j.jort.2016.09.002

Spandre, P., François, H., Morin, S., & George-Marcelpoil, E. (2015). Dynamique de la neige de culture dans les Alpes Françaises. Contexte climatique et état des lieux. *Journal of Alpine Research | Revue de Géographie Alpine*, *103*(2). https://doi.org/10.4000/rga.2840

Spandre, P., François, H., Verfaillie, D., Lafaysse, M., Déqué, M., Eckert, N., George, E., & Morin, S. (2019). Climate controls on snow reliability in French Alps ski resorts. *Scientific Reports*, *9*(1), 8043. https://doi.org/10.1038/s41598-019-44068-8

Steiger, R., & Mayer, M. (2008). Snowmaking and climate change. *Mountain Research and Development*, *28*(3), 292–298. https://doi.org/10.1659/mrd.0978

Steiger, R., Scott, D., Abegg, B., Pons, M., & Aall, C. (2019). A critical review of climate change risk for ski tourism. *Current Issues in Tourism*, *22*(11), 1343–1379. https://doi.org/10.1080/13683500.2017.1410110

Storper, M. (2011). Why do regions develop and change? The challenge for geography and economics. *Journal of Economic Geography*, *11*(2), 333–346. https://doi.org/10.1093/jeg/lbq033

Strambach, S. (2010). Path dependence and path plasticity : The co-evolution of institutions and innovation – the German customized business software industry. In R. Boschma & R. Martin (Eds.), *The handbook of evolutionary economic geography* (pp. 406–431). Edward Elgar Publishing. https://doi.org/10.4337/9781849806497

Trawöger, L. (2014). Convinced, ambivalent or annoyed : tyrolean ski tourism stakeholders and their perceptions of climate change. *Tourism Management*, *40*, 338–351. https://doi.org/10.1016/j.tourman.2013.07.010

Vanat, L. (2020). *2020 international report on snow & mountain tourism*. Laurent Vanat Consulting. www.vanat.ch/RM-world-report-2020.pdf

Vlès V. (1996). *Les stations touristiques*. Economica.

Williams, S. (2014). *Tourism geography : critical understandings of place, space and experience* (3rd ed.). Routledge. https://doi.org/10.4324/9780203743881

Wilson, G., Green, M., & Mack, K. (2018). Historical climate warming in the white mountains of New Hampshire (USA) : implications for snowmaking water needs at Ski areas. *Mountain Research and Development*, *38*(2), 164–171. https://doi.org/10.1659/MRD-JOURNAL-D-17-00117

Woolf, N. H., & Silver, C. (2017). *Qualitative analysis using NVivo : The five-level QDA method* (1st éd.). Routledge.

Zhe, W., Yiyi, J., Xinjian, L., Ning, W., & Yue, Z. (2022). Does Ski tourism improve the regional economy? The case study of Chongli, China. *Journal of Resources and Ecology*, *13*(4), 603–612. https://doi.org/10.5814/j.issn.1674-764x.2022.04.006