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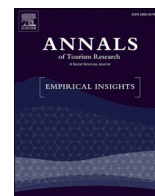
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## Assessing tourism capital using two-tiered empirical model

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### ABSTRACT

The study aims to develop a novel approach to assess Tourism Capital in resort areas, specifically Zermatt-Matterhorn, between 2014 and 2021. This approach integrates a two-tiered empirical model, where the first tier involves CNN-based image analysis, and the second tier employs mathematical techniques and time-series social media data to evaluate stakeholder engagement. The research emphasizes how fluctuations in tourism capital are influenced by stakeholder interactions and external events, highlighting the significance of empirical and quantitative approaches in understanding tourism dynamics. The findings underscore the substantial role of stakeholder engagement in shaping overall tourism capital, offering a practical and dynamic tool for tourism analysis and urban planning. This study innovatively assesses Tourism Capital by analyzing Instagram images, offering a more in-depth, data-driven view of tourism development in resorts.

### 1. Introduction

The evaluation of resort development has been extensively studied in the literature through diverse approaches over time. Research has examined changing spatial relationships (Gilbert, 1939; Miossec, 1976; Smith, 1992; Young, 1983), evolutions in visitors' psychological needs (Plog, 1973; Smith, 1989), and resort life cycle models (Butler, 1980). Other studies have analyzed the economic dimensions of resort growth, including the Resort Development Spectrum framed around market dynamics (Prideaux, 2000). Numerous frameworks and guidelines have also aimed to quantify environmental and social resort impacts using sustainability certifications and ecolabels (Eskerod & Đurić, 2018; Reid, Johnston, & Patiar, 2017; Roth, Lewis, & Hancock, 2021; Spenceley, 2018). Quantitative techniques such as statistics, econometrics, artificial intelligence, and complexity science have been applied to further analyze tourists' destination perceptions (Hurley, Moutinho, & Witt, 1998; Nunkoo, Smith, & Ramkissoon, 2013), forecast tourism demand (Deaton & Muellbauer, 1980; George, Osinga, Lavie, & Scott, 2016; Mariani, Baggio, Fuchs, & Höepken, 2018), and model destination structures and dynamics (Baggio, 2017). Visitor preferences and satisfaction with resort selection have additionally been explored through market segmentation (Inbakaran & Jackson, 2005). In summary, the

literature has evaluated resort development through spatial, psychological, evolutionary, economic, sustainability, and quantitative lenses.

Each of the proposed approaches provides valuable insights, but they also have limitations in fully capturing the complex, dynamic, and multifaceted nature of resort systems. Indeed, spatial and psychological models may overlook broader socio-economic and cultural impacts, a concern echoed in many studies (Chen, Lai, He, & Yu, 2020). Economic and market-focused models often sideline critical environmental and social sustainability issues (Skene, 2022). While sustainability frameworks address environmental and social factors, they may not adequately capture evolving tourist behaviors and preferences (Gössling & Lund-Durlacher, 2021). Similarly, quantitative methods, though valuable for data-driven insights, can overlook the nuanced, qualitative aspects of tourism experiences (Mieli, 2022). This indicates a need for a more integrated, interdisciplinary approach, combining these diverse perspectives to fully understand resort systems, as advocated in contemporary research (Clark & Wallace, 2015) and the UNWTO study (WTO, 1992).

The paper's distinctive contribution lies in its pioneering methodology for assessing Tourism Capital through the examination of Instagram images. Employing a two-tiered empirical model, this study introduces an innovative approach to comprehend the dynamics of

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resort development. The initial tier utilizes Convolutional Neural Networks (CNN) for precise image classification, while the subsequent tier presents a distinctive empirical model that scrutinizes social media data employing mathematical techniques and time-series analysis. This methodology marks a substantial departure from conventional approaches, providing a more exhaustive and data-driven insight into the evolutionary patterns of tourism in resort areas such as Zermatt, Switzerland. From a theoretical standpoint, the research advances the boundaries of tourism studies by reinforcing the concept of an integrated and systemic “tourism capital.” In terms of practical implications, this study introduces a scalable model that not only standardizes and streamlines the quantification of tourism capital stocks and flows but also facilitates effective comparative analysis and informed decision-making across diverse resort types. Additionally, it underscores the empirical and operational nature of the proposed method.

This paper is structured as follows: [Section 2](#) overviews existing research on touristic place development. The same section delves into the rationale for using Instagram data. [Section 3](#) outlines the new resort evaluation methodology. [Section 4](#) applies this to the Zermatt-Matterhorn case. Finally, [Section 5](#) concludes with the approach’s effectiveness in tourist resort analysis and future research directions.

## 2. Literature review

### 2.1. A brief overview of research into touristic place development

Current research on resort development identifies four key models: the life-cycle, restructuring, transformation of place qualities, and Tourism Capital. These approaches are briefly outlined, considering their limitations relevant to this study. [Stock, Clivaz, Crevoisier, and Kebir \(2021\)](#) offer a detailed critique of the first three. This study focuses on these established frameworks to assess their applicability and constraints in the evolving tourism sector.

The life-cycle approach, integrating the Christaller-Plog-Butler model for tourist area development, faces critiques for its narrow focus and oversimplification ([Stock et al., 2021](#)). It tracks transformation during development but neglects the sustained importance of places post-tourism decline, as seen in Brighton’s case ([Équipe, 2002; Stock, 2001](#)). This approach concentrates mainly on tourism, ignoring broader socioeconomic and urban dimensions and everyday local usage of urban services ([Stock et al., 2021](#)). It also misses varying evolutionary paths of resorts, like becoming cities or residential areas ([Équipe, 2011](#)), and simplifies historical and socio-cultural impacts, lacking specific timing in development stages ([Stock et al., 2021](#)). Criticism also includes its general assumptions about tourist capacity and ecological stability, especially in the Butler model ([Kruczek, Kruczek, & Szromek, 2018](#)). Francophone researchers, such as [Suchet \(2015\)](#), have questioned its geographical relevance in geographical studies.

The restructuring approach ranks second among the frameworks for analyzing resort development. This interdisciplinary method examines the social, political, and economic dimensions of a resort’s economic growth. However, its applicability is mainly limited to the UK context, as it was developed with a focus on British tourist culture until the 1970s ([Cooper, 1997; Demetriadi, 1997](#)). The model predominantly addresses the socioeconomic transformations in British society, particularly influencing the decline of tourist resorts. A significant limitation is its inadequate consideration of the diverse actors involved in tourism development and their impact on the sustainability or decline of touristic activities ([Stock et al., 2021](#)). While the approach does explore the evolving standards of tourism within a resort, it leaves uncertainties regarding how resorts adapt or evolve spatially, an aspect addressed by subsequent approaches.

The third approach to tourism research focuses on the spatial and functional evolution of tourist resorts, emphasizing their inherent ‘DNA’ and its impact on development. This method, detailed in works by [Stock et al. \(2021\)](#), explores the transition from tourist sites to resorts, tourist

enclaves to resorts, and resorts to touristified cities, with practical examples from Myrtle Beach, USA ([Santangeli Valenzani, 2022](#)), and the French Alps ([Tuppen & Langenbach, 2023](#)). It also considers the reverse scenario, where declining tourism transforms resorts into suburbs, recreational areas, or new tourist cities, as observed in Maspalomas, Spain ([Santana-Jiménez, Hernández, & Suárez-Vega, 2019](#)), and France’s Côte d’Albâtre ([Duhamel, 2008](#)). This model, applied in diverse settings including China, Malta, and Ireland ([Yeoman & McMahon-Beattie, 2019](#)), underscores tourism’s significant role in the geographical and historical evolution of destinations.

However, this approach predominantly focuses on just one aspect of resort development, often overlooking critical factors such as sustainable development and community engagement ([López, Virto, Manzano, & Miranda, 2018](#)), along with tourist participation ([Jebbouri, Zhang, Imran, Iqbal, & Bouchiba, 2022](#)), especially in the “invention process” and somewhat in the “subversion and diversion process” ([Équipe, 2005](#)). This is apparent in Jalisco, Maya Riviera ([Glup, 2021](#)), and Barcelona ([Crespi-Vallbona & López-Villanueva, 2023](#)). While challenging Christaller’s central place theory by underscoring tourism’s role in establishing a place’s “symbolic centrality” ([Monnet, 2000](#)), it falls short in comprehensively understanding this concept or delineating the factors that contribute to a destination’s regional or global prominence, as seen in cases like Florence or Bruges ([Duhamel, 2018](#)).

The “Tourism Capital” approach in resort evolution studies ([Stock et al., 2021](#)) identifies six key areas: resources, governance, urban environment, reputation, economy, and knowledge, further divided into sub-capitals (economic, political, knowledge, symbolic, spatial (urban), and resource capital) (see [Section 3.2](#)). This framework, as per [Colletis and Pecqueur \(1994, 2005\)](#) and further discussed by [Jeannerat \(2013\)](#), views these as tourism resources for stakeholder investment, facilitating global customer interaction. Incorporating various theories, including inhabiting, institutional resource regime, governance, and economic theories ([Clivaz, Nahrath, & Stock, 2011; Darbellay, Clivaz, Nahrath, & Stock, 2011](#)), this approach operates across multiple scales and interacts with different methodologies. It emphasizes the role of external stakeholders like journalists and tour operators in innovation ([Stock et al., 2021](#)), leading to the reinvention of local elements for new tourist resources, as seen in Baile Felix Spa Resort, Romania ([Trip, Simut, & Badulescu, 2023](#)), and other locales ([Russo & Richards, 2016](#)). The approach also recognizes the interaction between resorts and urban contexts, illustrated by studies in Macau, Vegas, and French communes under the SRU Law ([Hatt, 2012](#)). However, its limitation lies in using price as the sole resort measure, lacking practicality. To overcome this, a new empirical model using social media data has been developed for a comprehensive assessment of resort development, exemplifying a data-driven approach in resort evaluation.

### 2.2. Exploring the impact of social media and the metaverse on tourism: a focus on Instagram’s role

As highlighted by [Buhalis, Leung, and Lin \(2023\)](#), the Metaverse is expected to significantly transform travel and tourism management and marketing in the upcoming decades. This emerging platform offers new ways to engage with destinations, organizations, consumers, and local residents, potentially enhancing the overall user experience. Although still in an experimental phase, its impact on tourism is anticipated to be substantial.

Simultaneously, social media broadly influences travel decision-making, attracting significant attention from tourism scholars. Studies like those by [Leung, Sun, and Bai \(2019\)](#) and [Liu, Mehraliyev, Liu, and Schuckert \(2020\)](#) have explored the impact of social media on both the behavioral intentions and actual behaviors of tourists. These platforms act as critical sources of information and inspiration, playing a direct and indirect role in shaping travel choices and highlighting their comprehensive impact on the tourism sector.

Within the sphere of social media, Instagram particularly stands out,

especially in terms of user-generated content (UGC). Iglesias-Sánchez, Correia, Jambrino-Maldonado, and de las Heras-Pedrosa, C. (2020) emphasize Instagram’s extensive communication capabilities, from tourism branding to UGC photography. UGC, including likes, comments, photos, and follower interactions, is pivotal in forming a destination’s image, as shown in studies by Santos (2021), Baumann, Lopes, and Lourenço (2018), and Iglesias-Sánchez et al. (2020). This form of co-creation, involving a range of stakeholders like tourists, companies, and local communities (Buonincontri & Micera, 2016), plays a significant role in the scientific analysis and understanding of tourism trends and dynamics (Belchior Sousa, Fernandes, & Pequeno, 2021; Bernardino, Santos, Ribeiro, & Freitas, 2020; Wang, Huang, & Yao, 2021). Using social media UGC, such as that found on Instagram, to comprehensively and complexly evaluate a resort and its actors based on tourist and local community UGC is one of the contributions of this research to the existing body of knowledge.

Following the review of relevant literature, this paper introduces several key hypotheses, stemming from the discussions on touristic place development and Instagram’s role in research. These hypotheses are:

- How can tourism capital be assessed with greater precision?
- Can the evaluation be made more measurable?
- Can this assessment reveal the deeper identity of the studied resort?
- Would it be possible to study seasonality and measure the weight of the tourist practices proposed in each season for a resort?
- What is the weight of each stakeholder in the definition of the resort’s tourism capital?
- And how can the pace of life of the resort be analyzed?

This approach ensures that the hypotheses are rooted in a comprehensive review of existing research and the innovative use of primary Instagram data.

### 3. Methodology

The methodology follows a two-tiered empirical model,

comprehensively outlined in the flowchart (Fig. 1). The first tier, comprising Steps 1 to 3, involves CNN-based image analysis. The second tier, encompassing Steps 4 to 6, synthesizes mathematical techniques and time-series social media data to evaluate stakeholder engagement.

#### 3.1. Definition of image classes

CNN, as a prominent class of artificial neural networks commonly used for visual imagery analysis, have made valuable contributions to tourism studies. Examples include forecasting tourist demand data (Nguyen-Da, Li, Peng, Cho, & Nguyen-Thanh, 2023) and facilitating foreign tourists’ understanding of cultural norms (Hirotsu, Hirota, Araki, Endo, & Ishikawa, 2020). CNN have also aided urban studies through enabling prediction of urban expansion (Boulila, Ghandorh, Khan, Ahmed, & Ahmad, 2021) and assessing the effects of subjective and objective measures on housing prices (Zhu et al., 2023). However, the application of CNN to analyze multidimensional urban tourism within the specific context of resort social media networks has not yet been explored. This research gap motivates the current work, which focuses on classifying all images from the official Instagram pages of selected stakeholders representing a tourist resort.

The CNN model, as represented by Table 1, Fig. 1 and Fig. 2, was applied to a dataset comprising 19,857 images distributed across nine distinct classes. Python served as the primary programming language for implementation, with essential libraries such as Keras for model construction, NumPy for numerical operations, and OpenCV for image processing. The dataset was divided into training and validation sets, with 80% allocated for training and 20% for validation. Images were standardized to 128 × 128 pixels and processed using a batch size of 32. The Sequential CNN model was structured with Conv2D layers for feature extraction, MaxPool2D layers for dimensionality reduction, and Dropout layers to address overfitting, all followed by Dense layers for final classification. Activation functions, specifically ReLU and softmax, were applied to the model’s layers (Fig. 2). Notably, the model included 2,196,487 trainable parameters, highlighting its capacity to learn intricate features from input images and its effectiveness in image

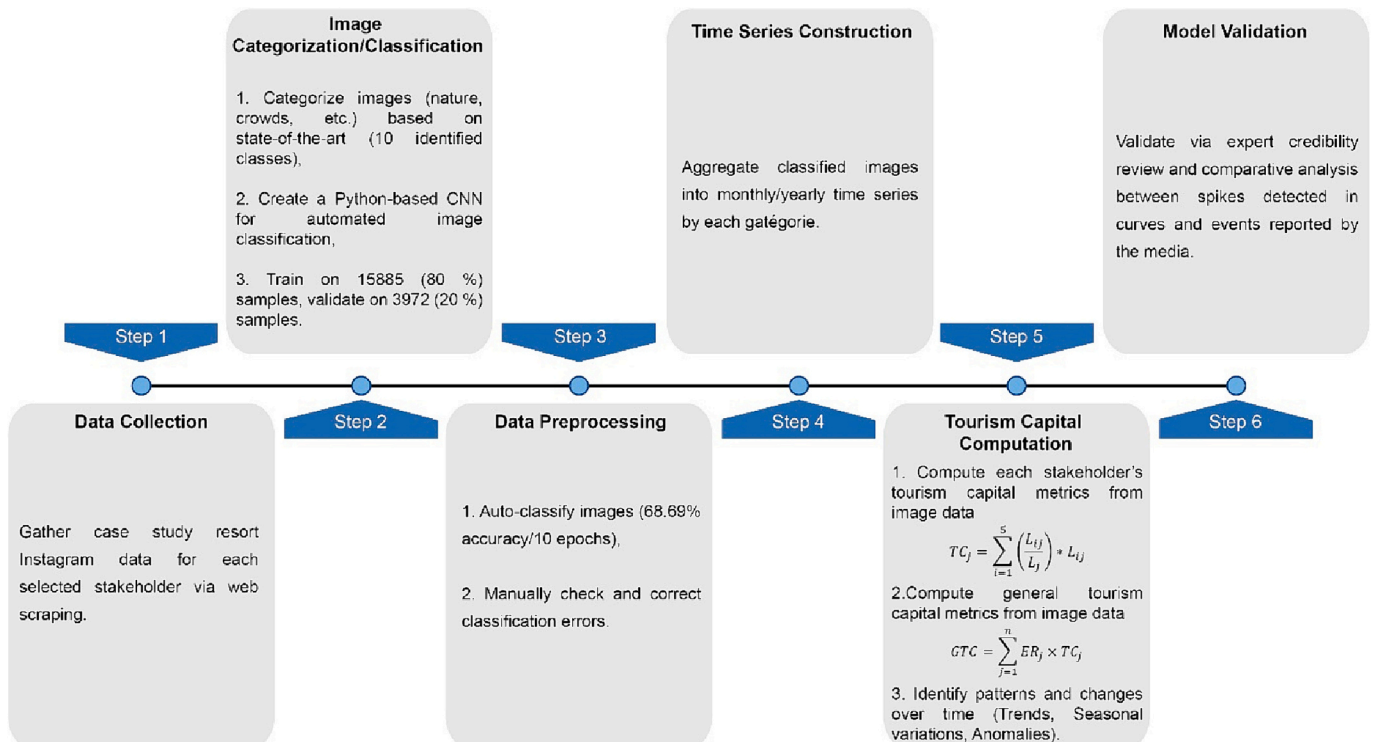


Fig. 1. Flowchart of the methodology’s model.

**Table 1**

The specific parameters of conducting and training CNN.

Content	Description
Dataset	19,857 images across 9 classes
Programming Language	Python
Libraries	Keras (model construction), NumPy (numerical operations), OpenCV (image processing)
Dataset Split	80% training, 20% validation
Image Size	128 × 128 pixels
Batch Size	32
Model Structure	Sequential CNN with Conv2D, MaxPool2D, Dropout, Dense layers, ReLU and softmax activation (Fig. 2)
Trainable Parameters	2,196,487
Dataset Structure	Organized into folders for classes ('final_data' folder)
Output Structure	Folders by year (level 1), then month (level 2), then classes (level 3)

classification tasks. The dataset, labeled as 'final\_data,' was organized into folders representing distinct classes (Fig. 3) and underwent pre-processing steps such as rescaling and augmentation, including shear transformation, zooming, and flipping.

The result (output) looks like Fig. 3. There are folders listed by year, and each yearly folder (level 1) contains twelve folders with the number of each month of the year (level 2). Each month's folder has content for each of the ten classes explained below (level 3). An initial image classification was conducted based on existing literature. Özdemir and

Çelebi (2015) proposed content-based categories such as Landscape: Coast, Landscape: Countryside, Cities and Attractions, Culinary, Events, Experiences, and Videos. An alternative content-based taxonomy by Nixon, Popova, and Önder (2017) used groupings such as Nature, Culture, Food and Drink, and Various. Building on these studies, a second stage involved developing a customized, empirical and interpretive taxonomy, supplemented by relevant academic works, to classify social media content related to tourism capital formation. The focus was on identifying key resource types and tourism stakeholders that shape destination evolution. The contents are explained in Table 2.

3.2. Regrouping classes by sub-capital

Except for the uncategorized class, the content of each of the other nine classes is inspired by the existing literature of image analysis. According to Pan, Lee, and Tsai (2014), the cognitive image would be related to tangible and intangible attributes. The first ones are expressed in the acronym INCA (Infrastructure, Nature, Culture, and Adventure). Infrastructure includes general and touristic buildings, roads, structures; nature includes natural resources and the natural environment; culture is associated with history and art; and adventure encompasses touristic recreation. As for intangible attributes, these are associated with political and economic factors, such as the social environment and the atmosphere of place. According to the scholars (Darbellay et al., 2011; Nahrath & Stock, 2012; Stock et al., 2021), the tourism capital of a resort is the place's set of the following characteristics: spatial, sociocultural, political, economic, and environmental. Therefore, six dimensions

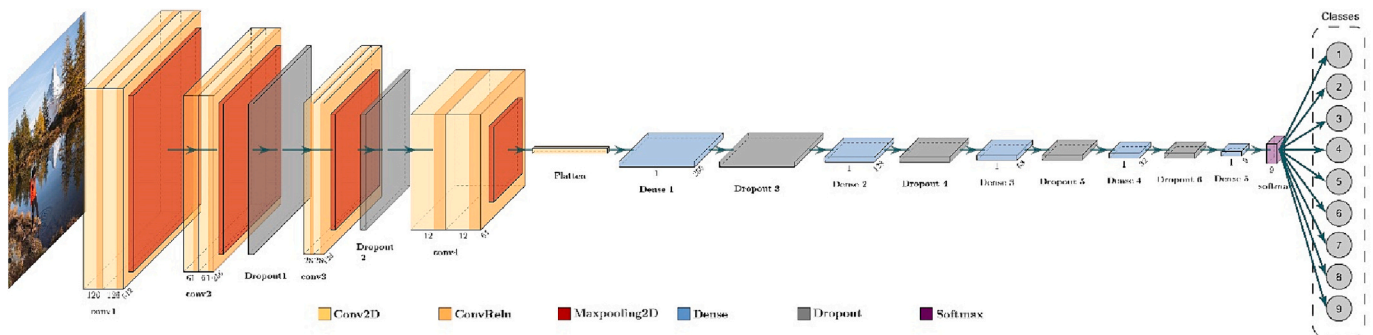


Fig. 2. CNN model architecture.

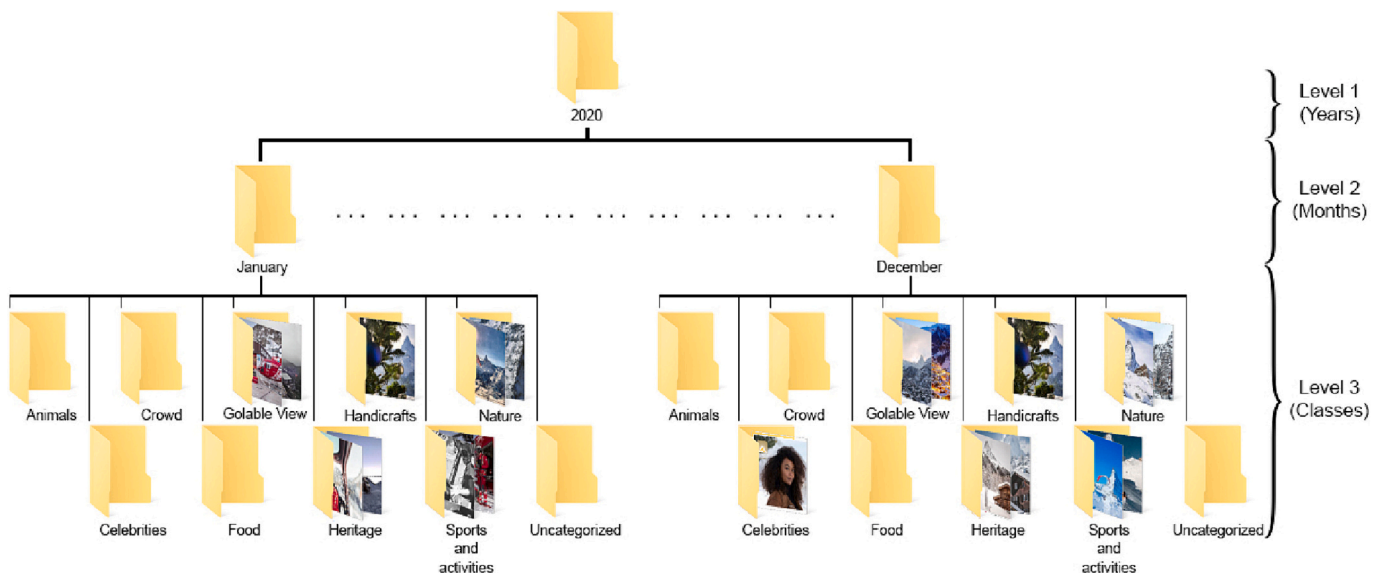


Fig. 3. CNN classification tree structure of all the images in an Instagram profile.

**Table 2**  
Explanation of the contents of each class.

Animals	A class that includes images of animals or where an animal element is central.
Celebrities	This is the class that contains images of celebrities in all fields (e.g., music, sport, culture). These images can illustrate the celebrities on stage, in a photo shoot, or on a poster announcing an event. This class includes images corresponding to
Crowd	- gathering places and events (concerts, public squares, streets) - beaches with lots of umbrellas and restaurants with tables (even if empty) - shopping and sociability links (MIT Team, <a href="#">Équipe, 2002</a> ; <a href="#">Équipe, 2005</a> ; <a href="#">Équipe, 2011</a> )
Food	A class containing images of dishes and edible products. This category groups images that include two or more other categories. For example, you can find images that contain the sea (e.g., foreground); an overall view of a village, an urban fabric, or part of a city (e.g., middle ground); and a snow-covered mountain (e.g., background).
Global View	This class contains images of handicrafts, artisans practicing their craft (e.g., engraving on brass, painting), art works, murals, products containing logos or branded images of places (e.g., pillows, bedsheets, hotel towels), and images showing furniture in close-up. This class contains the following items:
Handicrafts	- historic buildings: in general, this includes stone and wood in all their forms and in all the historical periods that they represent, from pyramids to medieval urban fabric - images of companies' holdings (e.g., trains, helicopters) - the interior of buildings, (e.g., individual rooms in the case of hotels and palaces) - equipment representing the location and which is photographed without the presence of humans (e.g., ski lifts, ski groomers)
Heritage and Holdings	Includes all images that contain, as their essential message, nature in all its forms (forest, river, mountain, snow). Minority presence of holdings and passive human presence (faces not visible or just a tiny presence on the whole image area) are considered in this class. This class includes three of the five motives for tourist travel theorized in the state of the art, namely rest, discovery, and play (MIT Team, <a href="#">Équipe, 2002</a> ; <a href="#">Équipe, 2005</a> ; <a href="#">Équipe, 2011</a> ), including
Nature	- images containing any other human activity, even professional ones (e.g., a lifeguard or helicopter pilot, a train mechanic) - images showing rolling stock with a significant human presence over the entire image area - images showing the human capital of companies (e.g., cook, chef, waiter, lifeguard, helicopter pilot)
Sports and Activities	This file includes only images that are not classifiable, such as advertisements and event announcements with a neutral graphic background (i.e., single color with text display)
Uncategorized	

following of the concept was considered:

- Symbolic capital: image of the resort, communication strategy
- Spatial or urban capital: location, urbanity, quality of places
- Resource capital: natural, mineral, and landscape resources
- Political capital: governance and power structures, as well as efficiency of public policies
- Knowledge capital: knowledge and innovation
- Economic capital: investment capacity

According to the authors, what makes this concept successful is its exhaustiveness, since it touches on several dimensions that together construct the tourist resort: material/immaterial or abstract; mercantile/nonmercant; anthropogenic/natural (mineral and organic); human (issues and interactions of stakeholders)/resources ([Colletis &](#)

[Pecqueur, 1994](#)).

### 3.3. Theoretical model

In what follows, the Tourism Capital was determined for each stakeholder by aggregating all the proposed sub-capitals. Eq. (1) calculates the Tourism Capital for stakeholder  $j$  ( $TC_j$ ):

$$TC_j = \sum_{i=1}^5 \left( \frac{L_{ij}}{L_j} \right) * L_{ij} \tag{1}$$

where.

$L_j$  : total number of likes for the stakeholder  $j$ .

$L_{ij}$ : number of likes per month or per year for the capital  $i$  and the stakeholder  $j$ .

The study identifies five distinct sub-capitals. The capital  $i$  can be: resource capital, urban capital, monetary capital, knowledge capital, or symbolic capital. More details are represented in [Table 3](#).

Upon computing the Tourism Capital for each stakeholder, the Global Tourism Capital (GTC) of the resort is determined, as defined by Eq. (2):

$$GTC = \sum_{j=1}^n ER_j \times TC_j \tag{2}$$

where  $TC_j$  is the tourism capital for the stakeholder  $j$ ;  $n$  is the number of stakeholders;  $ER_j$  is the engagement rate for the stakeholder  $j$ .

The GTC is the weighted average of all stakeholders' Tourism Capitals. The engagement rate is considered as the weight of each stakeholder's outcome. The engagement rate is the official measurement across social media platforms ([Jaakonmäki, Müller, & Brocke, 2017](#); [Stevanovic, 2020](#)). According to [Stevanovic \(2020\)](#), it is considered to be one of the main metrics to evaluate companies' social-marketing results ([Stevanovic, 2020](#)). It is also an indicator of performance enabling the evaluation of the destination image and the advertising efficiency ([Schreiner, Fischer, & Riedl, 2021](#)). Liking and commenting reflect the users' engagement vis-à-vis social media content ([Aramendia-Muneta, Olarte-Pascual, & Olló-López, 2021](#); [Yu & Sun, 2019](#)). Moreover, the number of followers is an indicator of popularity and hence mirrors the importance of network size ([De Veirman, Cauberghe, & Hudders, 2017](#)). Therefore, the engagement rate computation is built on the number of likes and comments and the number of the users' followers ([Swani, Milne, Brown, Assaf, & Donthu, 2017](#)).

Many scholars propose a different manner of computing the

**Table 3**  
Calculation of each sub-capital as a function of a class (per year / month).

Resource capital (RC)	Recurrence of likes for mineral, natural, or even immaterial image resources, which could be identified as associated by nature, animals, or food classes.
Urban capital (UC)	Quantifying the recurrence of likes for images of buildings and company holdings (heritage and holdings class).
Monetary capital (MC)	Recurrence of likes related to images illustrating the land potential as a whole (global view class) and recurrence of likes for images related to the economic dynamics of the place (crowd class).
Knowledge capital (KC)	Recurrence of likes of the images showing jobs or activities. In other words, publishing a photo of a group of kayakers implicitly communicates the resort's potential knowledge, supervision, and safety regarding this activity (sports and activities class and handicrafts class).
Symbolic capital (SC)	Number of likes for images containing famous people (celebrities' class).
Political or Governance capital	It would be impossible to include this sub-capital in the model since it would be difficult to interpret public policy decisions from the image content. However, the Tourism Capital curve could reflect this capital.

Source: Authors.

engagement rate. For their part, [Azmi and Budi \(2018\)](#) consider the value of comments as the highest level of engagement by multiplying it by 2 and weighting the value of likes by 1. Then, they divide the total value by 3, which represents the total value of Instagram user engagement. The decision was made to increase the total number of comments in the formula, following the approach of the previously mentioned authors. However, this did not have much impact on the final result. [Arman and Pahrul Sidik \(2019\)](#) adopt [Azmi and Budi \(2018\)](#) engagement rate formula (eq. (3)) by modifying the denominator:

$$ER = \frac{\sum_{i=1}^n (L_i + 2C_i)}{3nPF} \times 100 \quad (3)$$

where.

ER: the engagement rate.

L: number of Likes.

C: number of Comments.

n: Total number of posts.

P: Probability for followers to see posts.

F: Total number of followers.

Note: No scientific explanation has been identified for the use of P in the formula.

The study references [Bonsón and Ratkai \(2013\)](#) and [Molinillo, Anaya-Sánchez, Morrison, and Coca-Stefaniak \(2019\)](#) for the computation of the engagement rate using eq. (4). Given that the initial results were nearly zero, a multiplication by 1000 was proposed, mirroring the method used by the cited authors, to facilitate better comparative analysis.

$$ER_j = P_j + C_j + V_j \quad (4)$$

where P (popularity) is used to measure the attractiveness and notoriety of the user's images:

$$P_j = \left( \frac{L_j}{po_j * fo_j} \right) * 1,000 \quad (5)$$

where

$po_{ij}$ : the number of posts for the stakeholder  $j$ .

$fo_{ij}$ : the number of followers for the stakeholder  $j$ .

C (commitment) permits the evaluation of the level of followers' involvement with posted online content:

$$C_{ij} = \left( \frac{co_j}{po_j * fo_j} \right) * 1,000 \quad (6)$$

where  $co_j$  equals the number of comments for the stakeholder  $j$ .

The V (virality) of posts reflects the users' interest in the image content shared via social media. Following [Molinillo et al. \(2019\)](#), it is concluded that the virality formula cannot be applied due to the absence of the posts' shared data in Instagram:

$$V_j = \left( \frac{PS_j}{(po_j * fo_j)} \right) * 1,000 \quad (7)$$

where  $PS_j$  equals posts shared for the stakeholder  $j$ .

The final stage depicted in the flowchart ([Fig. 1](#)) encompasses the validation process of the model. This critical phase entailed a qualitative expert assessment and a comparative analysis conducted between spike detections in the data curves and events reported in the media. This comprehensive approach, which extends across various facets including model architecture, data preprocessing, and validation, serves to emphasize the robust methodology employed for the purpose of achieving effective CNN-based image classification in the context of the Zermatt resort.

## 4. Case study: The tourism Capital of Zermatt resort

### 4.1. Stakeholders' selection

The choice of actors is based primarily on the state of the art. Air Zermatt AG and Gornergrat are two key players in the resort since they contributed to the development of the ski activity in what [Roy, Guex, and Sauthier \(2012\)](#) calls the phase of predominance of skiing (1960–2010). [Guex \(2016\)](#) indicates that in 2013, the municipal and bourgeois communities constituting the tourist resort, the hotel association, the merchants' association, the Matterhorn Gotthard Bahn, the Zermatt Bergbahnen AG, the Zermatt Tourist Office, and the Matterhorn Group signed a charter providing for investments of CHF 1.2 billion in the following years. The author adds that the development of tourism in Zermatt owes much to its private actors, and in particular to the Seiler family, owners of Mont Cervin Palace. This information is confirmed by [Piquerey \(2013\)](#). Cervo Mountain Resort (Cervozermatt), a group of ecolodges, has been awarded an excellent rating by the professional hotel association Responsible Hotels of Switzerland. The inclusion of the Grand Hotel Zermatterhof in the selection is attributed to its historical significance as one of the first hotels to open in Zermatt. A member of the Historic Hotels Worldwide network, it is one of only seven Swiss hotels—and the only one in Zermatt—to join this global network. The last player in the table, Zermatt Unplugged festival, is one of the key players in the attractiveness of Zermatt's tourist image and is the event player with the largest budget (1.8 million Swiss francs) in the tourist resort ([Hrgovcic, 2020](#)). [Table 4](#) was subsequently developed:

### 4.2. Data extraction and image classification

The data were composed of photos published from January 2014 to April 2021 in the official Instagram pages of the mentioned stakeholders of the Zermatt resort in Switzerland (see [Table 4](#)). They were scraped using the Python library Selenium and then classified by referring to the CNN approach into the cited 9 classes. Due to the notably low number of images in 2014, the decision was made to exclude this year from the analysis.

### 4.3. Results and discussion

An overview of the Touristic Capital evaluation for Zermatt resort is provided for illustrative purposes. As discussed earlier, the data is classified into 9 classes: animal, nature, food, heritage, global view, crowd, handicrafts, sports and activities, celebrities. Unclassified images are stored in an 'uncategorized' folder. [Table 5](#) shows the relative frequency distribution of likes by category and stakeholder. As the likes for uncategorized images are significantly low or zero, particularly for stakeholders like "gornergrat," "montcervinpalace," "zermattbergbahnen," and "Matterhorn Gotthard Bahn," these images are excluded from the computation of Zermatt's Tourism Capital. Therefore, this capital is obtained from five associated sub-capitals, namely Resource Capital (RC), Urban Capital (UC), Monetary Capital (MC), Knowledge Capital (KC), and Symbolic Capital (SC). [Table 6](#) shows the different percentages of likes related to the proposed sub-capitals and stakeholders. This table reveals that 44.95% of total likes are linked to Zermatt Matterhorn's RC. Moreover, this stakeholder takes first place with a total percentage of 66.71%.

The Global Tourism Capital (GTC) was subsequently designed by aggregating the Tourism Capitals of all stakeholders. [Fig. 4](#) displays the breakdown of GTC into monthly data in its seasonal component, its trend component, and the remainder. Accordingly, this capital follows an upward trend attaining a peak of 11,020.42 likes in August 2020, followed by another one with a value of 11,325.43 likes in January 2021. However, after the last period, GTC steadily declined until reaching a value of 35.21 likes in April 2021 during the pandemic.

Moreover, a periodic fluctuation of 12 months is observed during the

Table 4

Presentation of the various stakeholders of the tourist resort Zermatt–Matterhorn, analyzed from their official Instagram page.

Stakeholder	Nature	Instagram profile name	Popularity (No. of subscribers as of 12/12/2022)	Last image	First image	No. of images	Total likes	Total comments
Public	Tourist office (commune)	zermatt.matterhorn (Zermatt–Matterhorn)	303,000	February 27, 2021	August 09, 2015	2017	7,455,161	20,218
Private	Air rescue company	Airzermatt (Air Zermatt AG)	68,900	February 25, 2021	December 31, 2015	663	15,142,663	3988
Private	Mountain resort	Cervozer matt (CERVO Zermatt)	32,100	February 25, 2021	February 26, 2015	1335	326,562	2866
Private	Railway company	Gornergrat (Gornergrat Bahn AG)	11,100	February 14, 2021	June 13, 2015	389	103,390	1168
Public/ Private	Railway company	Mgbahn (Matterhorn Gotthard Bahn)	6029	January 22, 2021	December 20, 2017	136	997,732	5771
Private	5* Superior luxurious hotel	Montcervinpalace (Mont Cervin Palace)	11,200	February 25, 2021	February 03, 2015	511	124,911	1855
Private	Switzerland's largest ski lift company	Zermattbergbahnen (Matterhorn Zermatt Bergbahnen)	34,800	May 06, 2021	July 15, 2015	821	553,713	3217
Private	5* Luxury hotel & Michelin Star restaurant	Zermatterh of (Grand Hotel Zermatterhof)	43,600	February 24, 2021	August 24, 2015	669	997,732	5771
Private	Acoustic music festival	Zermattunplugged (Zermatt Unplugged)	14,000	April 04, 2021	March 21, 2014	1054	127,178	1692

Source: Authors.

study period. Indeed, four positive peaks are observed throughout this period in each April, August, October, and December. Nevertheless, an important decline is seen in May, accompanied by two other periods of GTC decrease in September and November (see Fig. 5). This was confirmed by the (Grand Hotel Zermatterhof, 2024) Thomas Cook travel agency which indicated that the resort's peak season is from June to August and the shoulder seasons are between March and May as well as between September and November (Best Time To Visit Zermatt, 2024). According to them, the relative low season is during the winter in Zermatt.

The residuals are interesting, showing periods of high variability in the later years of the series. A peak is observed in December 2018 and August 2019. This may be explained by an increase in the number of followers during the period of the high season. This is reflected in the GTC graphical representation. Contrarily, a significant deterioration is observed in September 2020. The late travel magazine (Time Out, 2020) *Time Out* expressed the fear of the stakeholders: "...the tourism industry is worried that foreign travel quarantine restrictions imposed in Switzerland will severely damage what's normally a booming time for tourism".

The series also shows an important fall in tourism in March and April 2021. This worsening was a consequence of the COVID-19 pandemic. Indeed, as explained by a reporter for the *National Geographic* website, (D'Ignoti, 2021) Stefania D'Ignoti "the pandemic had significant economic repercussions on Zermatt's tourism economy: the town's tourist information office reports 45 percent fewer visitors compared to 2020. But even that diminished figure dwarfed visitation numbers in Italy, which did not welcome travelers".

In-depth analysis can be realized to explain the principal composition of each stakeholder's Tourism Capital. Fig. 6 exhibits the evolution of each stakeholder's Tourism Capital and sub-capitals per year. This graphic gives us a global idea of the principal contribution of each sub-capital to the Tourism Capital of the stakeholders. More specifically, according to Zermatt–Matterhorn's figure, the Tourism Capital evolution is somewhat similar to that of the resource capital. Indeed, 73.54% of likes are for images representing the resource capital. This can be explained by the fact that 98.51% of the images this public stakeholder posted to its Instagram account related to nature. Natural beauty may be considered for Zermatt–Matterhorn to be the main resource in the municipality.

For Zermattunplugged, Fig. 6 discloses that the Tourism Capital is

the aggregation of the following three sub-capitals: symbolic capital (31.09%), resource capital (27.97%), and monetary capital (27.68%). The festival is essentially based on the added value of its human capital represented by the classes celebrities (28.84%) and crowd (18.16%). However, it feeds its success by investing in the natural capital of the tourist resort, namely the nature class (23.53%), by building open-air stages.

Concerning the stakeholders specialized in transportation, almost all the figures show that their Tourism Capitals are mainly represented by resource capital with percentages greater than 45%, attaining 72.41% for gornergrat (see Table 7). However, for its part, airzermatt is characterized by resource capital (37.50%), knowledge capital (34.36%) and urban capital (23.37%). For all four transportation stakeholders, the nature class represents at least 92% of the resource capital. The urban capital, which is composed only of heritage and holdings, is also significant for zermattbergbahnen and Matterhorn Gotthard Bahn. This significance may be explained by the importance of images representing mainly their holdings, such as helicopters for Air Zermatt, trains for Matterhorn Gotthard Bahn and ski lifts for Zermatt bergbahnen. The knowledge capital is principally characterized for airzermatt and zermattbergbahnen by the sports and activities class, with percentages of 96.66% and 76.94%, respectively. This shows that, with the exception of Air Zermatt, all the stakeholders in the transport category communicate more via the images published on their Instagram accounts of the nature class than of the classes that represent human capital or rolling stock. This leads us to believe that if these stakeholders move away from Zermatt and the natural environment in which they operate, their reputation will drop drastically.

Regarding stakeholders specializing in accommodation and catering, such as Mont Cervin Palace and Cervo Zermatt, Fig. 6 depicts a similar graphical representation for each stakeholder's Tourism Capital and their resource capital. This capital is mainly represented by nature with 83.55% for Mont Cervin Palace and 64.27% for Cervo Zermatt. The percentage of food for the last-mentioned stakeholder with respect to the resource capital is also high (35.32%). For its part, Zermatterhof has the highest percentage of likes related to food with 54.41%. This can be explained by its qualification as its restaurant holds a Michelin star. The percentage of likes linked to nature images is also significant (41.45%). Indeed, this is one of the principal reasons for its classification as a five-star hotel. The information found on the official website of the hotel is as follows: "The Grand Hotel Zermatterhof has a long history of protecting



**Table 5**  
Percentages of total likes for Zermatt stakeholders and the studied categories for the entire resort.

Classes	airzermatt	cervozermatt	gornergrat	montcervinpalace	zermatt.matterhorn	zermatt.bergbahnen	zermatterhof	zermattunplugged	matterhorn.gothard.bahn	Total
Animal	0.06	0.00	0.02	0.03	2.77	0.07	0.11	0.01	0.00	3.09
Nature	5.06	0.59	0.63	0.41	44.95	2.02	1.12	0.26	0.18	55.23
Food	0.01	0.33	0.02	0.05	1.09	0.09	1.46	0.02	0.00	3.07
Heritage	3.20	0.95	0.13	0.24	5.29	1.47	2.59	0.10	0.08	14.06
Global View	0.54	0.26	0.01	0.10	5.81	0.13	1.14	0.08	0.03	8.10
Crowd	0.07	0.15	0.01	0.04	0.38	0.13	0.10	0.20	0.00	1.07
Handicrafts	0.16	0.51	0.01	0.05	0.49	0.21	0.79	0.02	0.00	2.25
Sports & Activities	4.55	0.10	0.10	0.15	5.58	0.71	0.75	0.01	0.04	12.01
Celebrities	0.04	0.00	0.00	0.04	0.01	0.00	0.14	0.32	0.00	0.56
Uncategorized	0.01	0.08	0.00	0.00	0.33	0.04	0.00	0.08	0.00	0.55
Total	13.70	2.98	0.93	1.11	66.71	4.88	8.19	1.13	0.33	100.00

Source: Authors.

**Table 6**  
Percentages of total likes for Zermatt's stakeholders and sub-capitals for all the entire resort.

Sub-capitals	Airzermatt	Cervozermatt	Gornergrat	Montcervinpalace	Zermattmatterhorn	Zermattbergbahnen	Zermatterhof	Zermattunplugged	Matterhorn.gothard.bahn	Total
RC	5.16	0.93	0.68	0.50	49.11	2.20	2.71	0.29	0.18	61.76
UC	3.22	0.96	0.13	0.24	5.32	1.48	2.60	0.10	0.08	14.14
MC	0.62	0.40	0.02	0.14	6.23	0.26	1.24	0.29	0.03	9.23
KC	4.73	0.62	0.11	0.20	6.11	0.93	1.54	0.04	0.04	14.31
SC	0.04	0.00	0.00	0.04	0.01	0.00	0.14	0.33	0.00	0.56
Total	13.77	2.91	0.94	1.12	66.78	4.87	8.24	1.05	0.33	100.00

Source: Authors.

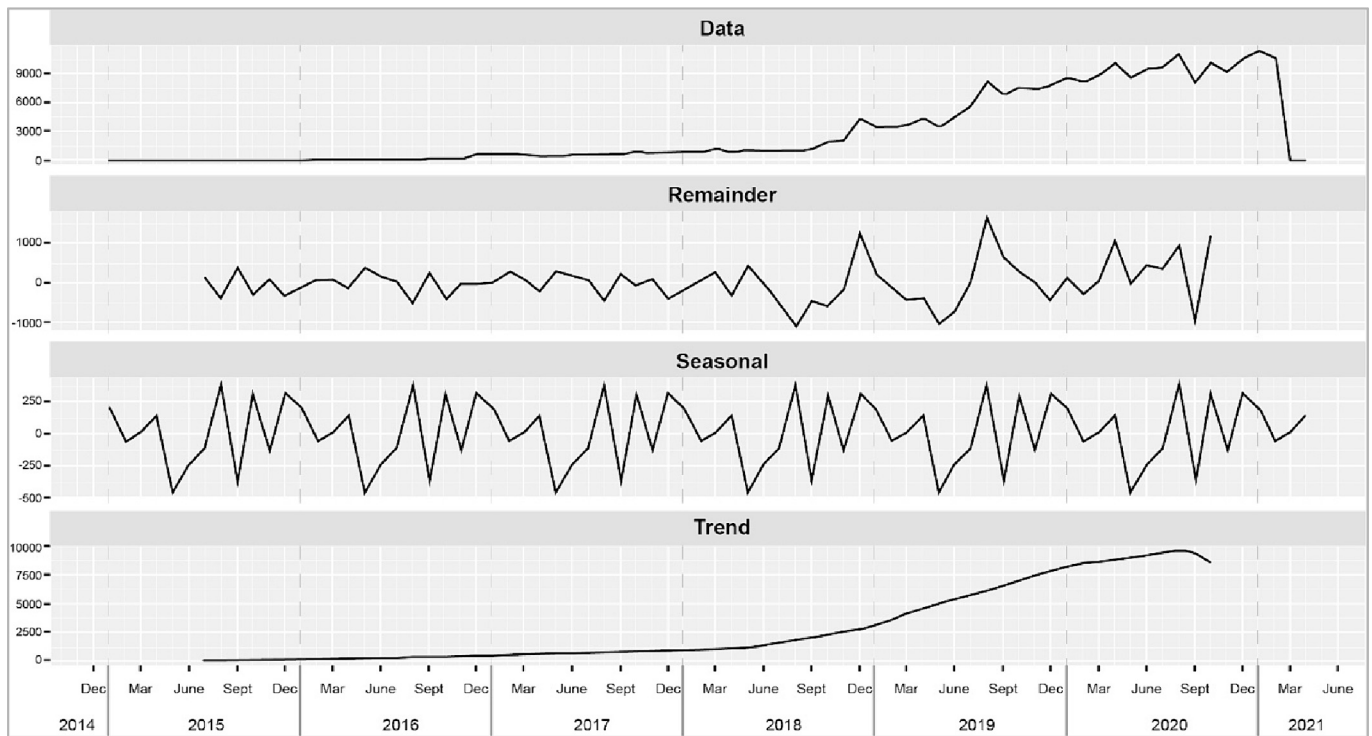


Fig. 4. Evolution of Zermatt's Tourism Capital (January 2015–April 2021).

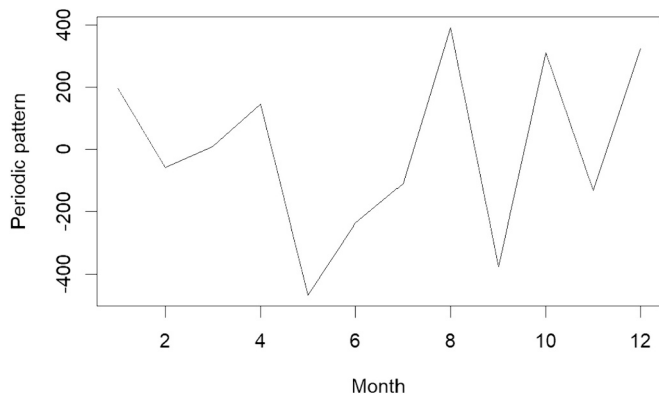


Fig. 5. Seasonality: periodic pattern over a 12-month period.

the natural setting is a fundamental resource for the success of their brand image communicating luxury and refinement.

Both Air Zermatt and Zermatt–Matterhorn captured the majority of total likes, but Air Zermatt received a much greater number of likes than Zermatt–Matterhorn. Nevertheless, the number of photos and the number of subscribers of Zermatt–Matterhorn’s Instagram page exceeds largely that of the Air Zermatt’s page. This is reflected in the engagement rate calculated on the basis of the formula proposed in the methodology section. Fig. 7 depicts the evolution of both Zermatt–Matterhorn’s and Air Zermatt’s Tourism Capital per month during the period of this study. Accordingly, Air Zermatt’s Tourism Capital curve is somewhat similar to GTC’s curve. However, when focusing on the remainder of the curve, a significant difference is observed in April 2020. Indeed, during this period, tourist flight operations fell sharply during the COVID-19 pandemic lockdown. The operations recovered slightly in May 2020. As Gerold Biner, CEO of Air Zermatt, has said: “Being able to slowly ramp up operations in the tourism sector, which have come to a standstill, is a relief for us and gives us more confidence for the rest of the financial year” (Cockpit Magazine, 2020) (Cockpit magazine). In addition, during the period May–September 2018, no image was published. This could be linked to the crash of an Air Zermatt helicopter into a lake near Heliport Raron or to the avalanche that occurred in the Zermatt resort area in January 2018. This latter incident, which did not record any victims, gives an indication of global warning and the improvement

the local natural habitat and continues to be committed to the sustainable development of the region.” (Grand Hotel Zermatterhof, 2024) Urban capital is also greatly significant with percentages of 32.90, 31.59, and 21.8 for Cervo Zermatt, Zermatterhof, and Mont Cervin Palace, respectively. Despite the fact that Zermatt attracts high-profile celebrities staying in hotels, including those mentioned in this article, they choose to communicate mainly in the nature category. For them,

Table 7  
Percentage of likes for each capital according to each stakeholder.

	airzermatt	cervozermatt	gonergrat	montcervinpalace	zermattmatterhorn	zermattbergbahnen	zermatterhof	zermattunplugged	Matterhorn Gothard Bahn
RC	37.50	31.95	72.41	44.53	73.54	45.22	32.88	27.97	54.29
UC	23.37	32.90	14.36	21.80	7.97	30.33	31.59	9.92	25.38
MC	4.50	13.86	1.82	12.44	9.33	5.36	15.08	27.68	8.62
KC	34.36	21.13	11.41	18.01	9.15	19.01	18.75	3.33	11.71
SC	0.27	0.16	0.00	3.21	0.02	0.09	1.71	31.09	0.00
Total	100	100	100	100	100	100	100	100	100

Source: Authors.

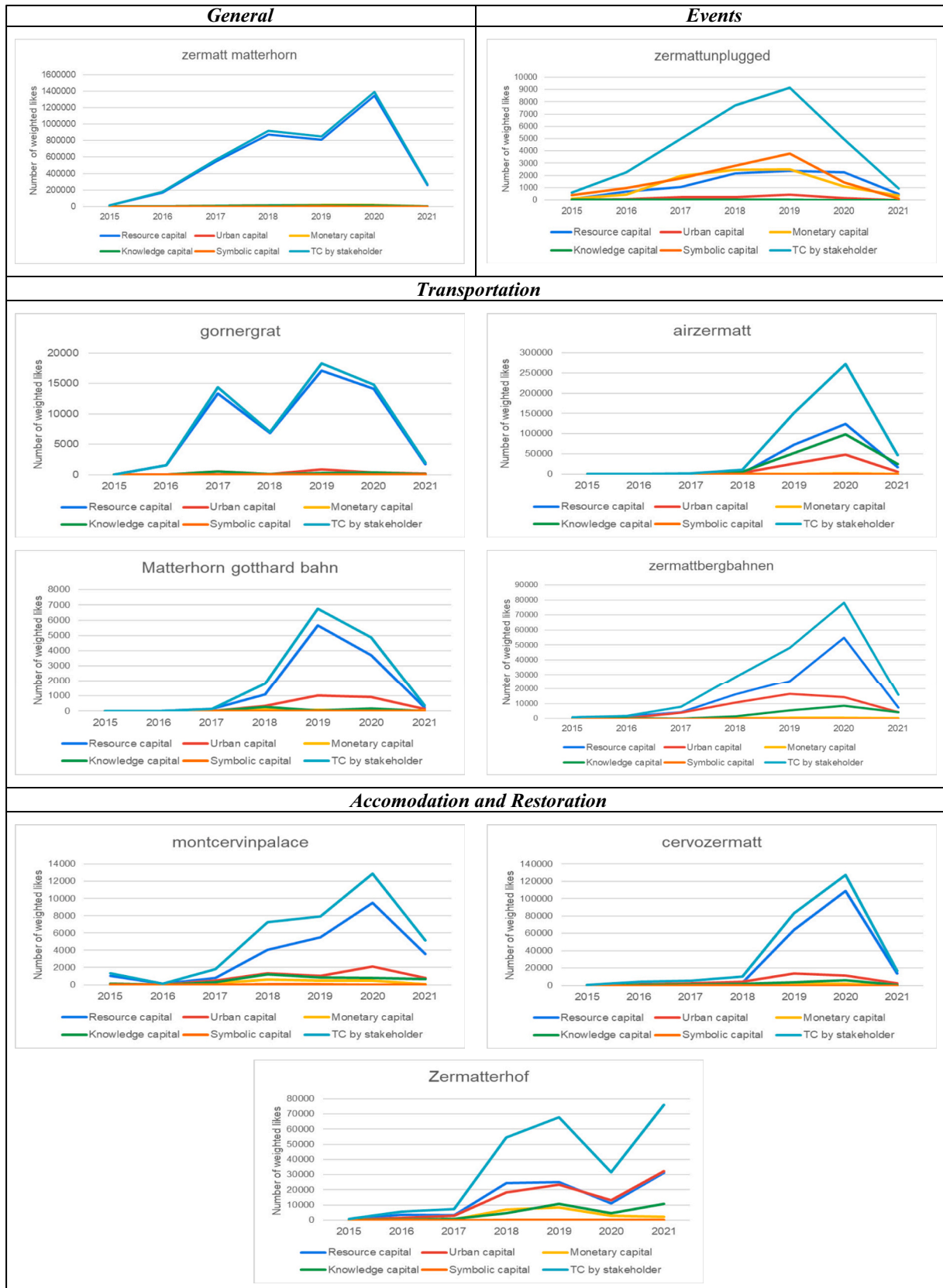
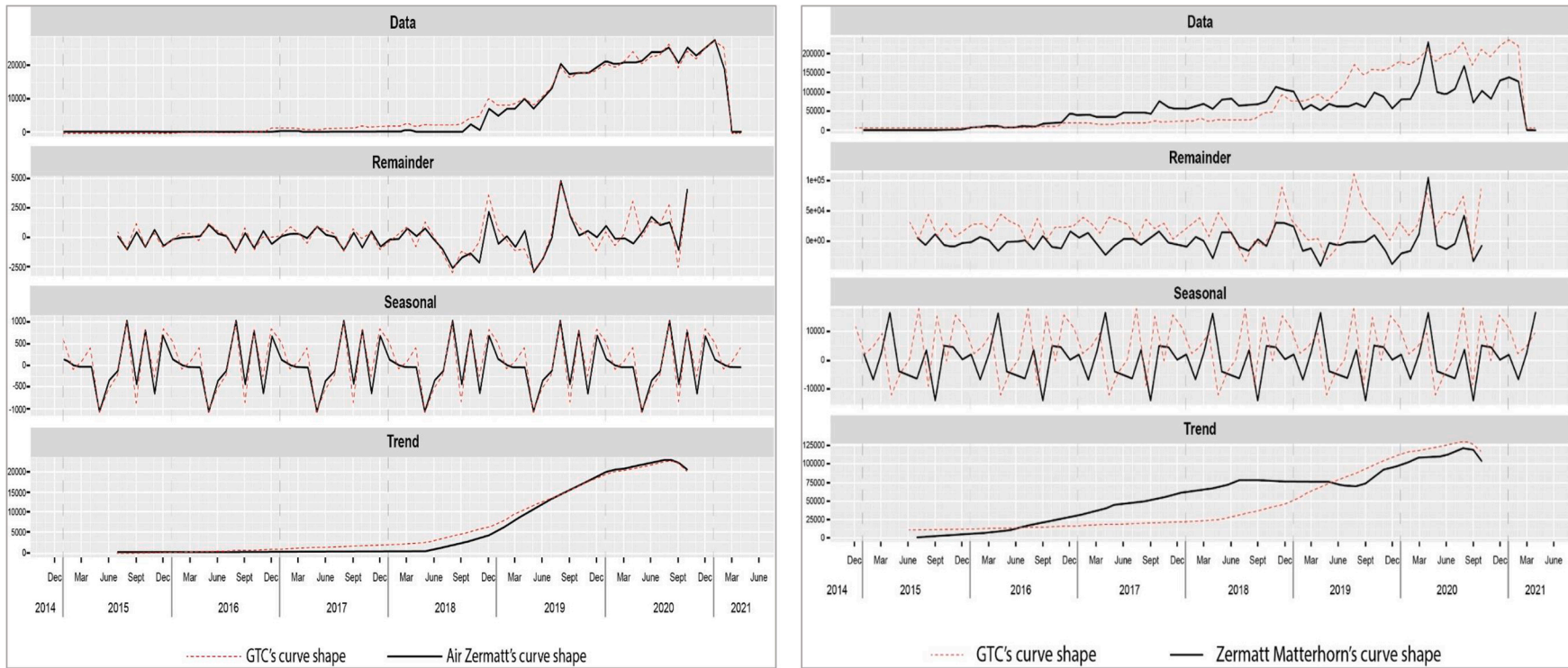


Fig. 6. Evolution of each stakeholder's Tourism Capital and sub-capitals per year.



**Fig. 7.** Comparison of the evolution of Zermatt–Matterhorn’s Tourism Capital and Air Zermatt’s Tourism Capital (January 2015–April 2021) (The GTC curve in dotted red is used to compare both stakeholders’ curves with that one). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of the security level due to the measures put in place after the previous avalanches (i.e., the avalanches in the winters of 1951, 1968, and 1999). As it happened, the resort waited for the avalanches of 1999 to create safety measures. However, using the suggested tool, the decline in the quantity of images relating to resource capital (mostly of nature) and, consequently, the number of likes, could also serve as a sign of climate change.

Regarding Zermatt–Matterhorn, significant fluctuations are observed in the remainder curve, specifically in April and September 2020 (refer to Fig. 7). Indeed, the tourist office, as well as the Zermatt Unplugged festival organizers, were attempting to make special preparations under unclear conditions due to the COVID-19 pandemic, hence the last-minute communication of images about the festival reflecting the exponential number of likes for the month of April alone. As the festival was cancelled at the last minute, the number of likes also followed the trend, which explains the free fall of the remainder curve in May.

Moreover, August 2020 registered the second peak in the curve resulting from the organization of the Enduro World Series Mountain bike race. Nevertheless, according to the COVID-19 government response stringency index composed of 18 restrictive measures including travel bans (Hale et al., 2021), tourists from the countries that are most represented in the official statistics for overnight stays in Zermatt, such as France, Great Britain and the United States, were affected by these restrictive measures. This effect led to a significant decline of Zermatt–Matterhorn’s Tourism Capital curve.

The results demonstrate the successful application of a novel method combining CNN-based image analysis and social media data to evaluate Tourism Capital in Zermatt, showcasing its fluctuating nature influenced by stakeholder engagement and events. This approach marks a new achievement in empirical tourism research, extending the concept’s applicability. The proposed hypotheses are examined through this model’s application, confirming their validity.

## 5. Concluding remarks

### 5.1. Conclusion

The study integrated two distinct models in its methodology. The first model was developed for classifying Instagram images into nine categories based on state-of-the-art literature, particularly focusing on the theoretical development of tourism capital. The second model utilized UGC and time series analysis, along with engagement rate calculations derived from the literature, to measure and evaluate the concept of tourism capital. This approach dissected tourism capital into specific components for each stakeholder and a cumulative global capital for the entire tourist station. These models were qualitatively validated by experts and presented at the international conference “9th Rendez-vous Champlain”. The study also underscored the importance of incorporating media events from reliable sources like National Geographic to validate time series analyses, especially where external factors like policy changes, natural disasters, or cultural events significantly impact data trends.

### 5.2. Theoretical implications

This research expands the conceptual, methodological, behavioral and organizational theoretical foundations in the area of tourist destination development and evolution. Indeed, the study advances theoretical boundaries in tourism research by reinforcing the concept of an integrated and systemic “tourism capital” proposed by Clivaz et al. (2011) and Darbellay et al. (2011). This notion encompasses the socio-technical complexity of tourist destinations. This enables more nuanced examination of destination development and evolution patterns beyond current theoretical frames. On a methodological level, the paper demonstrates the value of computational social science techniques to

advance tourism theory. This methodology innovatively integrates computer vision and time series analysis, thereby advancing the application of computational techniques within the domain of tourism theory. It establishes a novel paradigm for the modeling and understanding of intricate dynamics in tourist ecosystems. It provides a template for quantifying qualitative factors like visual imagery and experiential aspects that influence tourism capital. Moreover, the detected specific resources could inform urban and tourism planning through common goods concept (Buemi, 2021; Feinberg, Ghorbani, & Herder, 2021).

### 5.3. Practical implications

This study introduces a scalable model that not only standardizes and simplifies the quantification of tourism capital stocks and flows, enabling effective comparative analysis and informed decision-making across various resort types, but also emphasizes the empirical and operational nature of the method. Contrasting with more conceptual approaches to tourism capital, this method allows for real-time quantification and monitoring. Integrating deep learning visual classification and time series analysis of UGC, it extends practical implications for various stakeholders, demonstrating the effectiveness of a triple evaluation crossover involving tourists, locals, and resort stakeholders. This approach underlines the dynamic utilization of resort resources, enhancing strategic planning and resource mapping for state and urban/tourism institutions, and providing specialized study offices, large investors, and small investors with critical insights into the competitive landscape. Finally, specialized media can leverage this methodology to dissect the dynamics of tourist destinations and understand the influences of various stakeholders.

### 5.4. Limitations and directions for future research

The study has limitations, notably the recent Instagram data dating back only to 2015, which does not fully capture the early development of older tourist resorts established in the 1960s or earlier. Additionally, retrieving Instagram data is challenging due to platform restrictions, including account blocking. Furthermore, the potential bias in data due to stakeholders purchasing likes to boost their Instagram page’s popularity is a concern. However, this limitation also highlights the strength of the model, as it can detect such anomalies through residual curve analysis.

For future research directions, the framework can be expanded to include more destinations and further enhanced with additional data sources, such as analyzing the impact of celebrities. There’s potential to connect measures of tourism capital with financial valuations and sustainability objectives. Additionally, incorporating Facebook data for a comprehensive or comparative analysis with Instagram, possibly using natural language processing, is a viable option. Analyzing time series of overnight stays, Mueller and Sobreira (2024) found the COVID-19 pandemic caused significant forecast failures across all considered methods. This suggests leveraging time series of tourism capital evolution, rather than overnight stays, could prove a promising avenue for future forecasting analytics studies.

### CRedit authorship contribution statement

**Wadie Othmani:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Rym Ammar:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation.

## Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT 4 in order to improve language and readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

## Declaration of competing interest

None.

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