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The development of ski areas and its relation to the Alpine economy in Switzerland

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Abstract

Cableways alleviate access to the Alps and were crucial in establishing the skiing tourism boom of the after-war years. Moreover, cableway operators employ a large share of residents, are complemented by tourism-related services and are therefore a key economic pillar in otherwise laggard regions. We exploit comprehensive historical data of all ever-built cableways in Switzerland linked to income and population data to show how much ski area access benefits the municipalities' economy compared to similar municipalities without such access on their territory. Evaluating difference-in-differences, we find that opening a ski area between 1940 and 1980 is related to economic growth that persists until today. Particularly, it attracted new residents and created more productive employment opportunities in tourism-related services, thereby raising incomes and tax revenues. Our results contribute to the debate of what economic risks municipalities with access to ski areas face once the decreasing snowpack forces a ski area to close.

Keywords Tourism development, Economic development, Regional economics, Historical ski area data, Climate change exposure

JEL Classification N74, N94, O18, R11, Z32

1 Introduction

Around 70% of the Swiss landscape is covered by mountains that historically limited economic growth due to the complex topography and harsh climatic conditions. Consequently, most mountain villages and towns above a certain altitude experienced considerably lower population growth than low-altitude areas. Figure 1 depicts this by distinguishing the population development across altitudes. It shows that low-altitude municipalities quadrupled their population while less urbanized mid-altitudes grew only by 60% over the 170 years of observation. But why did the most remote high-altitude municipalities experience growth rates similar to those of low-altitude municipalities?

We reckon the answer is tourism. Striking indications of tourism as a major driver of this growth are the simultaneous emergence of the first cableways before World War I, the sharp population declines at high altitudes during the two world wars and the subsequent opening of ski areas in the aftermath of World War II.[1] Accordingly, we find that Alpine skiing tourism emerged in two periods with the help of historical accounts and cableways data (Bärtschi, 2015; Gross, 2023; Tissot, 2022). First, during the pioneering period between 1890 and 1940, innovative engineers competed for the most effective and secure way of transporting tourists close to the famous mountain peaks. At the time, skiing helped merely to operate

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[1] While the two wars waged in Europe, Swiss tourism development was disrupted by recessions, decreasing incomes, appreciating exchange rates, bureaucratic hurdles to enter the country, increasing public transportation prices and unforeseeable behavior of tourists (Tissot, 2022).

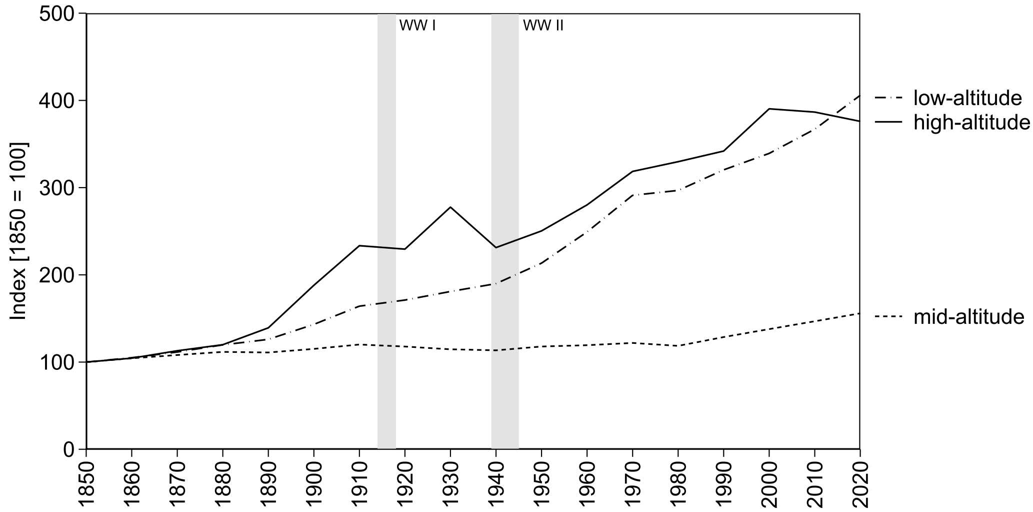

Fig. 1 Swiss population development across different altitudes. *Notes*: The lines indicate aggregated population counts of Swiss municipalities below 750 m.a.s.l. (low altitude: 1771 municipalities, 7977K residents in 2020), above 1500 m.a.s.l. (high altitude: 28 municipalities, with 47K residents in 2020) and at altitudes in between (mid-altitude: 376 municipalities, with 647K residents in 2020) indexed to 100 in 1850. The altitude of each municipality is measured at its historical center as defined by the Federal Statistical Office (FSO) (see Sect. 3.2)

the first racket railroads, funiculars and aerial cable cars in winter. After the Second World War, immense economic growth and the depoliticization, individualization and commercialization of leisure (Bandi Tanner and Müller, 2021) led to a nationwide skiing boom that drastically changed the primary purpose of cableways. During this second period between 1940 and 1980, therefore, the widespread opening of most ski areas took place.

In this paper, we focus on the second period, the ski area access period. In particular, we tackle the question of how municipalities that gained access to a ski area during this period developed economically relative to comparable Alpine municipalities that did not gain access to ski areas.

We link data from all ski lifts ever built in Switzerland aggregated to ski area access points to municipality-level data of population, employment, taxable income and federal tax revenues from the Federal Statistical Office (FSO) and the Federal Tax Administration (FTA). To ensure comparability, we retain a sample of Alpine municipalities that gained ski area access between 1940 and 1982 and a set of Alpine municipalities without such access. We then use a difference-in-differences (DiD) strategy to study the development of these municipalities and find that municipalities with access to ski areas have a 15.3 percentage points larger population growth on average and enable substantially more employment in tourism-related service sectors. In the long run, by 2015, employment in the accommodation sector is almost twice that of the municipalities without ski area access, the gastronomy sector is 45% larger and the retail sector 35%. Contrarily, the less labor-productive agriculture sector is 40% smaller.

Furthermore, we find that the rise of tourism-related services translates into 34.2 percentage points higher taxable income growth in municipalities with access to ski areas. These changes induced income differences that persist until today. After accounting for population growth and special cases (mostly foreign second home owners that pay federal taxes at the municipality of the second home), the residual taxable income growth rate is still around 14 percentage points higher. We argue that these changes originate primarily from individuals through (1) additional job opportunities that complement Alpine farming and construction work and (2) higher labor productivity across and within sectors. The former channel is consistent with formerly poor farmers and artisans finding work at better-paid service jobs in winter, by either substituting or complementing their previous jobs. Regarding labor productivity, we combine our sectoral employment estimates with productivity estimates from Rütter and Rütter-Fischbacher (2016) and find that the employment composition channel accounts for 2.9% of the residual change. Moreover, it is likely that agglomeration forces (i.e., having a larger population and, for example, larger hotels) led to more productive firms in municipalities with access to ski areas compared to firms of the same sector in municipalities without access.

The extension of the population and the higher employment rates led to substantial tax revenues for the municipal government. We find, on average, 51.6 percentage points higher federal income tax revenue growth and 38.0 percentage points per resident compared to the municipalities without ski area access. As the federal tax is a relatively constant share of cantonal and municipal taxes within the municipalities, equally sized gains can be expected for the local tax revenues.[2]

We contribute to several strands of the literature. The first strand deals with typical winter destinations' difficulty in adapting to climate change and the long-term consequences that they face. In particular, warming temperatures due to climate change threaten the natural snow reliability of ski areas (Elsasser and Bürki, 2002; Gonseth, 2013; Gössling et al., 2012; Koenig and Abegg, 1997; Marty et al., 2017; Scott and Gössling, 2022; Steiger et al., 2015) and, with them, sales of tourism-related service industries (Lohmann and Crasselt, 2012; Wallimann, 2022). To understand the adverse effects of so-called Lost Ski Area Projects (LSAP) (Schuck and Heise, 2020) and the declining tourism on the local economy, it is crucial to understand the positive impact of emerging ski areas in the first place. Our work contributes to both sides of the story.

Related to these challenges, we contribute to the debate on the efficacy and efficiency of public involvement in ski areas. Most ski areas are either through subsidized funds or ownership supported by the public (Derungs et al., 2019; Lengwiler and Bumann, 2018; Schuck and Heise, 2020). The primary goal of this support is to reduce regional disparities (Hoff et al., 2021).[3] On the contrary, municipal governments might use their additional tax revenues from the increased economic activity to fund expensive skiing infrastructure replacements. For example, Derungs et al. (2019) describe that the financial involvement in tourism infrastructure correlates with the financial capacity of municipalities in the canton of Grisons. We contribute here by showing that municipalities with access to ski areas indeed generate larger municipal tax revenues and that the financial flows between ski areas and municipal governments go both ways. However, as research shows, the path dependence arising from these tax revenue and investment cycles is not necessarily a threat to economic growth once the natural advantage is lost (Bleakley and Lin, 2012).[4]

Finally, we contribute to the literature on the emergence of tourism and its socioeconomic impact. During the emergence of ski areas, the operator firm employs workers and the municipalities with access to ski areas require accommodations to host the expected tourist inflows (Wallimann, 2022). Because tourists consume more than skiing, demand for complementary products and services such as ski schools, equipment rentals and sales rise (Lohmann and Crasselt, 2012). Research in various other contexts stresses that the emergence of tourism fosters economic growth (Favero and Malisan, 2021; Nocito et al., 2021; Pigeassou, 1997). Nocito et al. (2021) find that a television series boosted tourism in the municipalities used for filming. A 10% increase in total tourist expenditure translates into 4.7% more municipal income, 11.5% more firms and 10.1% more workers in tourism-related services. Favero and Malisan (2021) show how the Italian city Matera profited from the 2019 selection to the European Cultural Capital beyond tourism-related services. Moreover, they find substantial positive effects for cultural, infrastructure-related and real estate employees. Faber and Gaubert (2019), studying the long-term economic consequences of tourism in Mexico, find additionally positive economic spillovers of touristic activities to the unrelated manufacturing sector. Our work confirms tourism-led growth but, in contrast to Faber and Gaubert (2019) and Favero and Malisan (2021), only to sectors directly related to tourism.

Furthermore, our documented shift from agriculture to services while bypassing rises in manufacturing is, interestingly, a common pattern in many developing economies such as India (Fan et al., 2022). Strengthening consumer-based service industries is seen as a viable alternative in fighting poverty instead of relying on capital-intensive manufacturing (Blake et al., 2008; Croes, 2014; Faber and Gaubert, 2019; Fan et al., 2022; Spenceley and Meyer, 2012). In our context, however, the emergence of a manufacturing sector was rather constrained by the lack of space and accessibility than the lack of financial capital. This might be the very reason why we find no local spillovers to the manufacturing sector but an increasing dispersion of population, income and tax revenue across space.

The paper continues as follows: Sect. 2 provides the history of ski area development. Section 3 describes the sample, various data sources and summary statistics. Section 4 leads through the empirical strategy and its identification which brings us to the results in Sect. 5. We conclude in Sect. 6.

[2] The Swiss pay income taxes to three federal tiers: The federal taxes levied by the Swiss Confederation, the cantonal taxes by the cantons and the commune taxes by the municipalities.

[3] Skiing activities generate all kinds of externalities such as greenhouse gas emissions, biodiversity losses, health benefits and accidents. However, the central argument for the subsidies is reducing regional disparities. Hence, we focus on studying this "necessary condition" for the subsidies while leaving other effects aside.

[4] Bleakley and Lin (2012) document the ongoing importance of historical portage sites in the USA, although their initial use has become obsolete. Municipalities with ski area access have larger populations, as in Bleakley and Lin (2012), and might thus perform better than those without access even after losing such access.

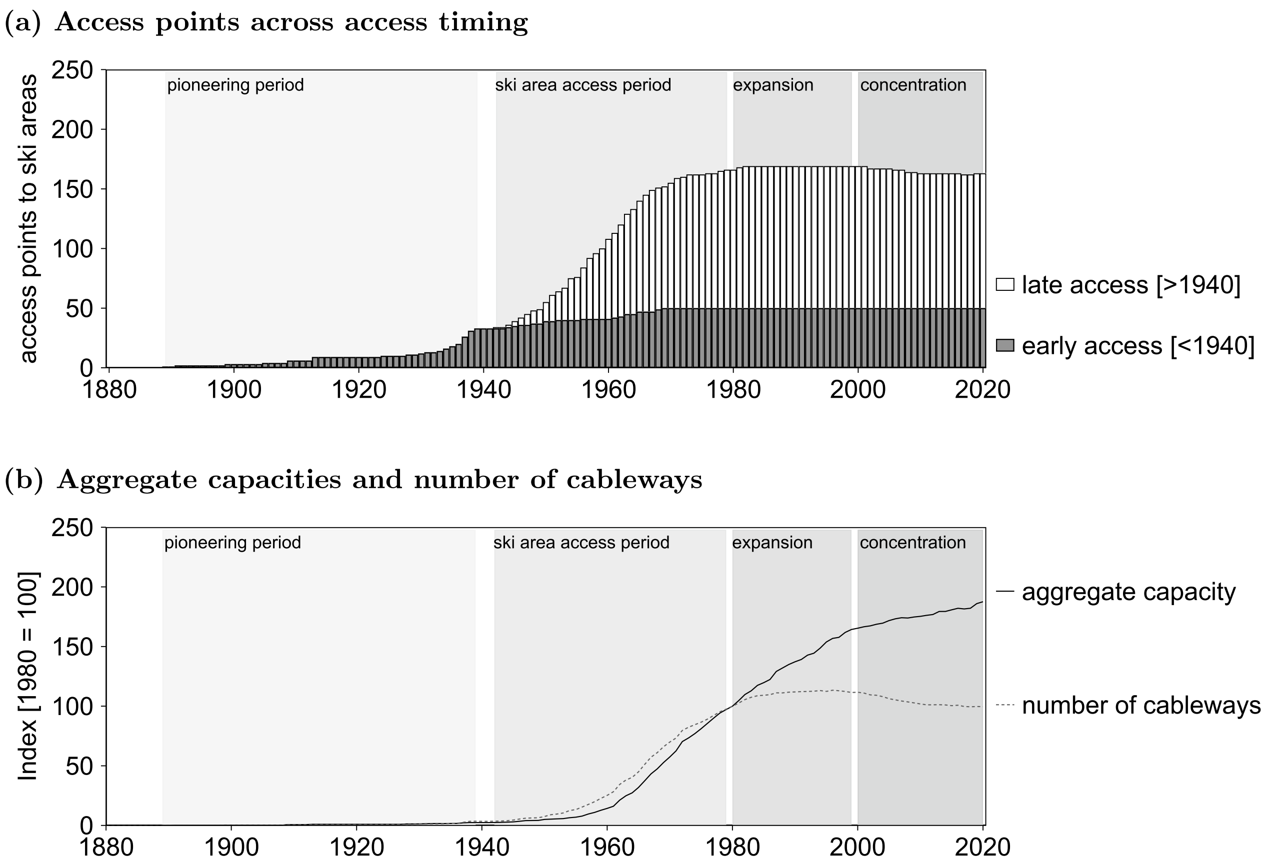

Fig. 2 Development of ski areas *Notes*: The bars in panel **a** indicate Swiss ski area access point counts in municipalities with at least one access point before 1940 (gray bars) and after 1940 (white bars). The solid line in panel **b** shows the aggregate capacity of all lifts in all ski areas (measured as the number of persons lifted by 1 km per hour) and the dotted line shows the overall number of cableways. Both are indexed to 100 in 1980. The two panels cover the last 140 years across four periods of ski area development

2 History of ski area development

The history of ski areas in Switzerland goes back to the eighteenth century. Thus, we split the history into four development periods based on historical accounts of Bärtschi (2015), Tissot (2022), Schuck and Heise (2020) and Büchel and Kyburz (2020). These are the pioneering period (1890–1940), the ski area access period (1940–1980), the expansion period (1980–2000) and the concentration period (2000–2020). Figure 2 depicts ski area growth across the four periods by showing the number of access points to ski areas distinguished by the time the municipalities gained access in panel (a) and by showing the aggregated capacities and number of lifts in panel (b).[5] Panel (a) in Fig. 2 shows the total number of ski area access points at two municipality types. The gray bars indicate access points that emerged in municipalities with a first access point during the pioneering period. The white bars indicate those that emerged in municipalities during the next period, the ski area access period. Some gray-labeled bars grow after 1940, indicating emerging ski areas with access points to municipalities that already had access to another ski area before 1940.[6]

Before the construction of cableways, the first documented tourism in a broader sense than some single travelers wandering to distant lands emerged in Switzerland around 1780–1830, when wealthy persons hoped to achieve fame by climbing the untouched peaks of the Alps. Back then, unsafe means of transportation, traffic routes, lodging and international tensions hindered traveling. The emergence of the European and Swiss

[5] A ski area access point represents the departure of a cableway that allows skiers to enter a ski area. As our unit of interest is the municipality and ski areas can sometimes be entered from multiple municipalities, having access to a ski area is the relevant measure to distinguish the municipalities. See Sect. 3.3 for further details.

[6] A prominent example is the ski areas around Davos and Klosters. The first access to Schatzalp was built in 1899 (at first not a ski area), to Parsenn in 1931 and at Bolgen in 1934 (which was extended to the Jakobshorn in 1954). After 1940, three additional ski areas were built: Madrisa in 1965, Rinerhorn in 1969 and Pischa in 1967.

railway network, the birth of the modern Swiss democracy, the introduction of a single currency and road improvements removed some of the objections to tourism after 1850 (Büchel and Kyburz, 2020; Tissot, 2022).

The first period of ski area development, the pioneering period, began in 1890 when large and prestigious tunnel and racket railway projects such as the *Gotthard Tunnel* or the *Gornergrat-Bahn* in Zermatt facilitated access to the Alps. During this period, skiing and other winter activities emerged and helped the seasonal hospitality industry capitalize on the winter season. This fostered investments into grand hotels in Alpine municipalities that provided safe accommodation close to the Alpine peaks and could, at a later stage, when winter sports became more attractive, be run in summer and winter (Tissot, 2022). Up to 1940, less than 50 access points could be used for skiing (gray bars in Fig. 2). However, skiing and tourism were often not their primary purpose. Instead, the goal was to meet military objectives, transport material for mining activities and provide transportation for residents (Bärtschi, 2015). The technical difficulties motivated innovative Swiss engineers to reach mountain tops with various lift systems such as racket railways, funiculars or cable cars. The dominance of winter sports in mountain areas started in 1934 when the first T-bar lift was opened in Davos but kicked off after the Second World War, establishing ski areas with a new variety of lift types tailored to transporting skiers (Bärtschi, 2015).

The ski area access period began after the Second World War. The economic boom years that followed amplified ongoing trends in individuals' recreational opportunities, such as a rising life expectancy (and corresponding progress in health), increasing wealth and incomes,[7] urbanization, commuting and car ownership, and reduced working hours (Bandi Tanner and Müller, 2021).[8] The rise in individual leisure opportunities was coupled with a surge in population.[9] Mass tourism emerged and a boom in skiing tourism occurred, fueling investments in ski lifts. The skiing infrastructure projects during this access period are the main focus of this paper. Consider the white bars in Fig. 2: Approximately 100 new ski area access points were built between 1950 and 1970 alone, and by 1980, the 191 ski areas[10] were offering 1,893 cableways that could lift 420K persons by one vertical kilometer per hour.

The third period from 1980 to 2000, called expansion, was marked by large investments within ski areas. By the first federal Land Use Planning Act ("*Raumplanungskonzept*," Federal Assembly of Switzerland, 1979) adopted in 1980 and the federal tourism concept ("*Tourismuskonzept*") from 1979, the construction of new ski areas from scratch was limited to some rare exceptions (Bandi Tanner and Müller, 2021; Krippendorf, 1983; Lendi, 2010). During this period, most cableways had to be renewed or were replaced by high-capacity lifts. Typically, surface lifts (like T-bars and platter lifts) were replaced by faster aerial lifts (like detachable chairlifts). Correspondingly, aggregate lift capacities increased by 69% within this period.[11] Consider again panel (b) in Fig. 2 that shows how aggregate lift capacities (as the number of persons that are lifted by 1 km per hour) and the number of cableways evolved relative to 1980.

The last period, the concentration period, is characterized by stagnating demand (Schweiz, 2018), a decline in the number of ski areas, but a 19% increase in aggregate lift capacities. We document nine lost ski area projects and three large mergers during this phase. The decline in Swiss ski areas is associated with several potential supply- or demand-side causes. On the supply side, climate change exposes ski areas to reductions in natural snow reliability (Elsasser and Bürki, 2002; Gonseth, 2013; Gössling et al., 2012; Koenig and Abegg, 1997; Marty et al., 2017; Scott and Gössling, 2022; Steiger et al., 2015) or operators were over-optimistic in their business cases attracting support by private and public funds (Schuck and Heise, 2020). On the demand side, substitutes for leisure activities (such as warm beach destinations and city trips, see Müller-Jentsch, 2017), relative prices (exchange rate appreciation and price reductions for air travel, see Abrahamsen & Simmons-Süer, 2011; Müller-Jentsch, 2017; Plaz & Schmid 2015) and changes in the potential skiing population (such as an aging population in Germany or a tendency to shorter vacations, see Lütolf et al. 2020; Plaz & Schmid 2015) all contribute to a decrease skiing demand. Operators react by increasing competition over prices and infrastructure (Lütolf and Lengwiler,

[7] Aggregate incomes almost quadrupled and more than doubled per capita in real terms between 1947 and 1980. The federal income of taxpayers grew from 1.2 Million to 2.5 Million over the same period.

[8] Before the Second World War, Swiss workers usually worked 48 h per week, which was reduced to 44 h by 1971. On top of that, the 5-day week became established in 1960 (Degen, 2015).

[9] The Swiss population increased by more than 40% from 4.6 Million to 6.4 Million between 1947 and 1980. Population data for 1947 are imputed from municipality-level counts of 1941 and 1950 (see Online Appendix A.4).

[10] A ski area is defined as a connected cableway cluster of at least two cableways over time. See Sect. 3.3 for a detailed definition.

[11] Although the federal tourism concept did not intend large capacity increases, many operators and municipalities favored such enlargements because of the suggestive and non-binding nature of the federal tourism concept (Bandi Tanner and Müller, 2021; Krippendorf, 1983) The high-capacity investments during this period lead to high replacement costs today and reduce the ability of operators to finance replacements themselves (Bieger and Laesser, 2005; Derungs et al., 2019; Lengwiler and Bumann, 2018; Schuck and Heise, 2020).

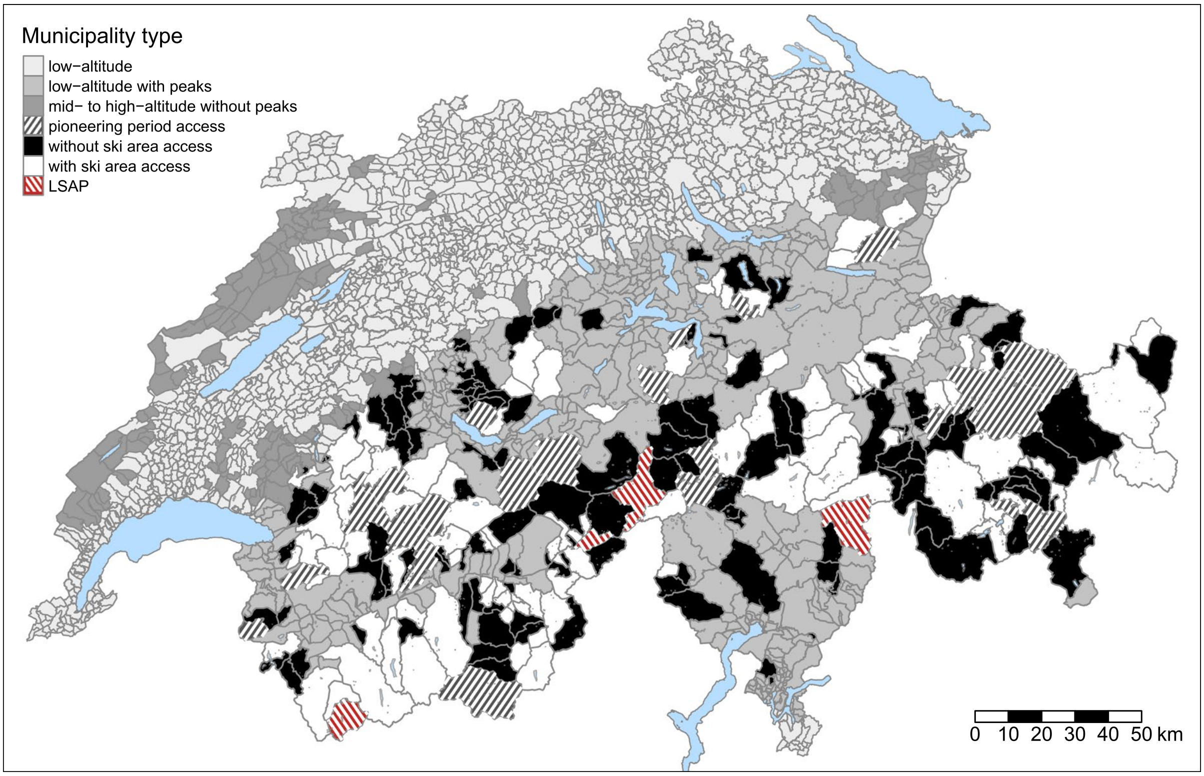

Fig. 3 Municipality types in 2021. *Notes*: The map indicates Swiss municipalities in 2021 jurisdictions separated into 7 categories based on altitude and whether a municipality is surrounded by sufficient peaks to be added to our sample. White and black areas indicate the municipalities in our sample. All other categories are defined as described in the text. A more detailed map that includes all ski area access points is provided in Online Appendix A.2.5

2015; Lütolf et al., 2020; Wallimann, 2022) of which already large, higher-lying areas seem to gain the most (Schuck and Heise, 2020).

3 Data

3.1 General data sources

We are interested in the economic development of Swiss municipalities that gained access to a ski area between 1940 and 1982. Therefore, we combine municipality-level data on ski areas, geographical features, population, employment, tax revenue and income from various sources.

We use publicly available municipality data from the center of competence for geoinformation and digital image processing (GEOSTAT) at FSO and match it with Alpine peaks from the Federal Office of Topography (swisstopo) and cableways data from the online platform *bergbahnen.org* (Gross, 2023). GEOSTAT data cover municipality borders and the center coordinates. We additionally use municipality mergers and splits back to 1960 from the FSO (see Online Appendix A.1).

3.2 Sample

We restrict our sample based on geography to obtain one set of municipalities that gained access to a ski area and a comparable set that did not.

Figure 3 displays the sample by separating municipalities across three dimensions: The municipality centers' altitude, a peak measure cutoff and the timing of gaining access to a ski area. The municipality center is defined by the FSO and described that it was carefully chosen at the center of a municipality's main village/town with an accuracy of 100 m. It is often set at the church, the central village square, at the municipal government or the main crossroads (Federal Statistical Office, 2021). The peak measure indicates how many Alpine peaks lie around the municipality centers. It is increasing in the altitude of the peaks, the proximity to the center in the three-dimensional Euclidean distance and the number of peaks (see Gutiérrez et al., 2010 for literature that uses similar gravity-based measures and see Online Appendix A.3.1 for an exact definition).

Ultimately, the municipality altitude and the peak measure proxy for how remote a municipality is and whether it is potentially attractive for skiing. The altitude singles out Alpine municipalities with harsher winters regarding temperatures and winds. Both measures relate to constrained economic development. The peak measure gives an idea of how mountainous the lands are. In addition, it partly indicates whether the surrounding landscape is attractive for skiing. Peaks provide slopes and attractive views at the same time. Accordingly, ski areas are often named after the highest peak that can be reached with its cableways (e.g., Schilthorn, Jakobshorn, Titlis, Nax-Mont Noble and Les Diablerets to name just a few).

The sample consists of municipalities indicated in white and black in Fig. 3. The former are municipalities that gained access on their jurisdictional territory to at least one ski area between 1940 and 1982. The latter are comparable Alpine municipalities that never had access to a ski area on their territory. For simplicity, we refer to them as municipalities with and without access to ski areas, respectively. All other municipalities are excluded from the sample for either reason:

1. Municipalities labeled as "low altitude" are in the Midlands, where the topography is too flat and the altitude is too low to build ski areas. Most of the largest Swiss cities and towns are located there.
2. Municipalities labeled as "low altitude with peaks" are below 750 m.a.s.l. but are surrounded by peaks and sometimes even have access to ski areas. These are often located on wide valley floors near large lakes or rivers and are well connected to large agglomerations.[12]
3. Municipalities labeled as "mid- to high altitude without peaks" are primarily found in the Jurassian mountains and are below the tree line. As with the "low altitude with peaks" group, these municipalities are much more accessible and are topographically distant from the Alpine municipalities.
4. We exclude gray-hatched municipalities labeled as "pioneering period access." These had access to cableways before the first ski areas emerged and could build a ski area around their existing infrastructure without much effort. Such a first-mover advantage makes them hardly comparable to municipalities that built ski areas from scratch.
5. We exclude red-hatched municipalities connected to LSAP that were either unsustainable in their economic or climatic prospects (Schuck and Heise, 2020). Notice that this choice induces a survivorship bias. However, we are concerned with the policy implication of municipalities potentially losing their ski area access and not of municipalities gaining new access. Therefore, we restrict the sample to those municipalities exposed to such a possibility.[13]

Our resulting sample consists of 227 municipalities in the Alpine region that are above 750 m, are surrounded by Alpine peaks, have no pioneering period access and are connected to ski areas in operation. Of those, 94 are in the group with access and 133 are in the group without access.

3.3 Ski area access

We define a ski area as a cluster of cableways that consists, on average, of at least two lifts throughout its existence. The idea is to separate municipalities with small, often community-run village lifts from those that built ski areas to attract tourists. On top of that, lifts with a primary use other than winter sports are also excluded. These are excursion lifts and urban lifts.[14] Our remaining ski areas count to 190.

To aggregate these ski areas to our unit of interest, the municipalities, we define access points at which a ski area can be entered and allocate these geolocations to the municipality borders of 2021. A ski area can sometimes be accessed from multiple municipalities, whereas some municipalities have access to more than one ski area. Thus, our primary indicator, ski area access, is defined as having access to at least one ski area at a given time. Furthermore, we construct a capacity variable that captures all lift capacities that can be accessed from a single access point to that municipality. Further details on the definition and aggregation process can be found in Online Appendix A.2.

We document nine LSAP in our data.[15] From these lost projects, only three municipalities are entirely affected. Ernen, Obergoms and Bourg-Saint-Pierre. All other LSAP were accessed from municipalities connected to other ski areas or were built before 1940 (e.g., the first lift at Confin in San Bernardino was opened in 1939) and thus excluded anyway.

[12] For example, Lucerne or municipalities in the Rhone Valley. Both were historically well connected by highways and early railways (Büchel and Kyburz, 2020) and are, thus, topographically and economically very distant from the municipalities we intend to study.

[13] Additionally, we remove Einsiedeln and Oberhünigen (due to missing observations), and the two Comunanza's Capriasca/Lugano (TI) and Cadenazzo/Monteceneri (TI) (not inhabited).

[14] Many large cities in Switzerland built funiculars to transport residents and commuters uphill—for example, the Marzilibahn in Bern or the Polybahn in Zurich.

[15] These are: Bourg-Saint-Bernard, Confin, Ernergalen, Hungerberg, Isenau, Loutze, Monts Chevreuils, Schwyberg and Solacyre.

3.4 Geography

In addition to the municipality center altitude and the peak measure, we complement the municipality data with other geographical features:

1. The road distance to the next cantonal center is used as a proxy of economic accessibility. This measure is computed using the Here Application Programming Interface (API).[16]
2. Lakes attract residents and tourists (Leuba, 2019; Waltert et al., 2011). Therefore, we compute the road distance to the next lake covering an area of at least one km^2 to measure this attractiveness with the Here API.
3. Using a three-dimensional shapefile from swisstopo, we measure developable land as the share of the suitable area over the whole municipality area. The suitable area is computed by identifying 158-by-158 m cells with an average slope below 15° and within 200 m in altitude of the municipality center. The idea is to proxy the size and space on the valley floor that can be used to develop buildings of any kind (historically, before the emergence of zoning laws). Details on how we construct this measurement are in Online Appendix A.3.2.
4. We construct additionally a measure of sunshine exposure of that developable land. For each 158-by-158 m cell, we compute the sunshine exposure on a typical winter day (when the sun is relatively low) using the rayshader package in R (Morgan-Wall, 2023) and calculate the mean sunshine exposure among all developable land cells in a municipality. More sunshine is considered attractive for housing (Leuba, 2019) and preferred by skiing tourists (Haugom and Malasevska, 2019). Details on how we construct this measure are in Online Appendix A.3.3.

3.5 Population

The population data are from the FSO and includes Census (VZ), Population and Households Statistics (STATPOP) and *Statistik des jährlichen Bevölkerungsstandes* (ESPOP) data (Federal Statistical Office, 2023a, c, e). All three sources represent essentially the same data for different periods with minor changes in data acquisition and, thus, structural breaks at the changes. VZ data are available for every decade between 1850 and 2000 except 1890 and 1940, where the data are available for 1888 and 1941, respectively. These years and the population counts in 1947 and 1975 are imputed to link them to other data using average yearly population growth rates. (We refer to Büchel & Kyburz, 2020, or Online Appendix A.4.2 for details on the imputation.) ESPOP data are from 1981 to 2010 and STATPOP from 2011 to today. The ESPOP data were harmonized with the VZ data at each decade. Further inconsistencies appear in 2011 from the change of ESPOP to STATPOP. The complete description of the data sources is in Online Appendix A.4. The municipalities Kandersteg and Icogne are merged with their neighbors Kandergrund and Lens in all estimates going further back than 1910, as these two municipality pairs were split from their neighbors between 1900 and 1910.

3.6 Economic activity

We use employment, tax revenue and income data as variables measuring economic activity. In addition, we complement the data with value-added estimates by Rütter and Rütter-Fischbacher (2016) to explore how sectoral labor productivity differences affect incomes.

Employment data are available from the FSO statistic Statistik der Unternehmensstruktur (STATENT) on the 6-digit International Standard Industrial Classification (ISIC) level between 2011 and 2017 (Federal Statistical Office, 2023d). Within this short period, no substantial structural changes occurred (Bandi Tanner et al., 2021) that substantially shifted the sectoral labor composition in the studied municipalities. Because the gross domestic product (GDP) estimates are only available for 2015, we use STATENT data from that specific year as well.[17]

The tax revenue and income data are gathered from publicly available municipality-level federal tax records between 1947 and 2017 from the FTA. The data from 1959 to 1972, 1987 to 1988 and 1997 to 2002 are incomplete or missing altogether (Federal Tax Administration, 1950, 2022). Due to these gaps and the availability of GDP estimates in 2015, we mainly use data from 1980 and 2015[18] and build long differences to 1947, the oldest data available.[19] Furthermore, we deflated all income

[16] We compute the road distances with the Stata command *georoute* (Weber and Péclat, 2017) that is based on the Here API, a company that provides location data and maps. Notice that road travel time has substantially changed over time through infrastructure investments. We argue that this affects the distances covered by roads less than the actual travel time and is thus a valid proxy of economic accessibility.

[17] We are mainly interested in the sectoral labor composition of the Alpine municipalities and use the GDP estimates for a back-of-the-envelope calculation of income differences across municipalities. As the local GDP estimates do not perfectly coincide with our study area and are likely subject to the business cycles around 2015, we suggest interpreting the estimates resulting from this exercise with caution.

[18] Year-to-year variation in economic activity is negligible at the very long time horizons we study here.

[19] We digitized the data between 1947 and 1958 and connected it to already digitized data from 1975 onward. See Online Appendix A.6 for details of this process. Six municipalities in our sample had already gained access to a ski area before 1947. These are Ormont-Dessus (1942), Château-d'Oex (1944), Flims and Tujetsch (1945), Beatenberg and Leukerbad (1946).

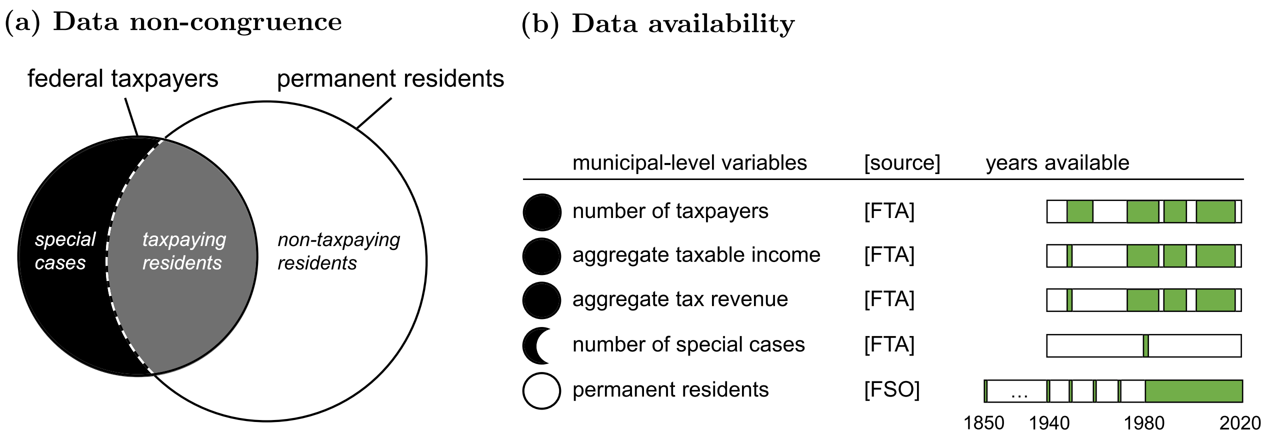

Fig. 4 Federal tax and population data availability. *Notes*: The two circles in panel **a** depict the non-congruence of the population and tax data. The legend in panel **b** shows the corresponding variables, their sources and for which years each variable is available

data to 1947 CHF using a historical consumer price index from the FSO (Federal Statistical Office, 2023b) to sustain comparability over time. We collect three variables across time and municipalities from the FTA data: The aggregate tax revenue, the aggregate taxable income and the number of federal taxpayers.

A limitation of the federal tax data is that it contains only the income from the taxpayers. Generally, these are taxable incomes that surpass the minimum threshold of the federal tax of individuals. These taxes are mostly collected from individuals who pay their federal income taxes at the municipality of legal domicile, which is normally the residence municipality at the end of the year. However, we have no information on the incomes of individuals exempt from the tax (due to very low incomes) and from individuals who are taxed at the source (typically foreign seasonal workers).

Additionally, the number of federal taxpayers contains so-called special cases, which can be further split into three groups: First, the interim special cases contain residents with substantial income changes during the tax period (about to be added to the normal cases in the next period). The second group is the lump-sum-taxed foreign nationals whose taxes are up for negotiation. The third group, called other special cases, contains primarily taxable incomes from foreign individuals economically "bound" to Switzerland but with legal domicile outside of Switzerland, including those that generate income from owning a second home (Federal Assembly of Switzerland, 1990; Federal Tax Administration, 2023).[20] We gathered the number of all special cases in 1980 for each municipality. Unfortunately, we have limited information on the municipal composition of special cases.[21]

We cannot construct a meaningful per capita income measure because the special cases prevent the tax and population data from being congruent. To see this, consider panel (a) in Fig. 4. The two circles depict that the population and tax data overlap, but both contain counts of individuals that are not part of the other. As special cases are often foreign second home owners that are taxed based on their income generated from these homes (either rental income or a similar tax based on a hypothetical rental value called "*Eigenmietwert*"), their average taxable income is much lower than the typical resident's income. And because we cannot distinguish the taxable income generated by residents from the income generated by special cases, a per capita measure has no clear interpretation.[22]

We isolate per capita income changes without having a measure for it by considering the changes in the number of residents falling in a specific tax regime. That is, by looking at changes in the normal cases (depicted as taxpaying residents in Fig. 4). As some residents fall under the interim and lump-sum special cases, retaining only normal cases ensures that all remaining individuals are taxpaying residents.[23] In addition, because we only have

[20] Other special cases further include the few residents with foreign income, married persons who died within the period and persons who receive capital settlements instead of recurring benefits, e.g., from pension funds. (see Federal Assembly of Switzerland, 1990; Federal Tax Administration, 2023, for further details).

[21] Figures from the canton of Grisons indicate, however, that in 1980, 46% of all special cases are interim special cases, 1% are foreign nationals under lump-sum taxation and 53% are other special cases, of which the largest group are foreign second home owners (Federal Tax Administration, 2023).

[22] Dividing the aggregate taxable income by all taxpayers (to construct a per capita measure) leads to a lower figure the more special cases there are.

[23] Interim special cases are added to the normal cases in the subsequent period and follow thus the same trend as the taxpaying residents. Lump-sum special cases amount to less than 1% of all special cases in 1980 and are thus irrelevant.

municipal information on special cases in 1980 (see panel (b) in Fig. 4), we have to assume little or no special cases in 1947.[24] Then, increases in the number of taxpaying residents originate from either new residents moving to a municipality (enlarging the white circle in Fig. 4), more individuals surpassing the minimum federal income tax threshold or more individuals entering the labor force (both shift individuals from the white to the gray area in Fig. 4). Therefore, observed changes in taxpaying residents reflect changes in per capita incomes once we account for population growth and changes at the extensive margin of labor volume.

3.7 Summary statistics

Summary statistics of the data for the whole sample, the municipalities with access (AC) and the municipalities without access (NAC) to ski areas are displayed in Table 1.

The municipalities with and without access are very similar in geographical features, except that the average municipality with access covers a larger area (at municipality borders in 2021), lies at a higher altitude and has less developable land at its disposal. The latter two are likely interrelated as valleys become narrower the higher their altitude. All other geographic measures are close to being indistinguishable. Most importantly, the peak measure indicates a strong similarity between the municipalities in our sample. In addition, we show that geographic factors partly determine where ski areas have been built, but not exclusively. Many municipalities without access are surrounded by suitable skiing terrain but refrained from investing in skiing infrastructure. See Online Appendix B.1.

The population distribution is right-skewed, with a few large and many small municipalities. The municipalities with access already had, on average, 50% more permanent residents in 1850 and grew faster than those without access.[25] Moreover, the number of taxpayers was, on average, already 60% greater in 1947. This suggests that larger municipalities, in terms of permanent residents, area and number of taxpayers, provided a more suitable environment to establish ski areas.

The distributions of the economic activity measures are also right-skewed, where the municipalities consist of many small jurisdictions and a few very large. The employment differences between municipalities with and without access are substantial and, most notably, greater than the differences in permanent residents. This indicates a higher employment rate in municipalities with access to ski areas when measured in full-time equivalents (FTE).

Looking at the tax base, it is striking how little it was in 1947. Only 1 out of 8 residents was liable to pay federal income taxes. Therefore, the average municipality generated only 6 CHF federal income tax revenue per resident on average.[26] By 2015, per capita incomes in the average municipality more than doubled, the number of taxpayers increased to 50% of the population and tax revenues are more than 20 times higher in real terms (in per capita and overall terms).

4 Method

4.1 Empirical strategy

To study the development of municipalities connected to ski areas, we use a two-by-two DiD strategy:

$$\ln y_{jt} = \alpha_t + \beta D_{jt} + \gamma_j + \varepsilon_{jt} \tag{1}$$

where $\ln y_{jt}$ is the logarithm of the outcome (population, income or tax revenue) in municipality j at time t. D_{jt} is a ski area access indicator. It equals 0 for all municipalities in the baseline period (t_0). It equals 1 for the second period (t_1) for those municipalities that gain access to a skiing area. Municipalities that never had access to a ski area indicate $D_{jt} = 0$ at both t. α_t is a year fixed effect, γ_j a municipality fixed effect and ε_{jt} is the error term.

We estimate β in (1), the association of ski area access to the outcome in period t, in first differences. This cancels time subscripts and allows a simple implementation and interpretation as a cross-sectional estimation using ordinary least squares (OLS). In particular, we estimate:

$$\Delta \ln y_j = \Delta\alpha + \beta D_j + \epsilon_j, \tag{2}$$

where $\Delta \ln y_j = \ln y_{j,t_1} - \ln y_{j,t_0}$ is the difference of the outcome between the two periods, $\Delta\alpha = \alpha_{t_1} - \alpha_{t_0}$ is the constant, $D_j = \Delta D_{jt} = D_{j,t_1} - D_{j,t_0}$ is the access indicator that equals 1 if municipality j has ever access to at least one ski area in the ski access period (in which almost all ski areas in our sample were built, see Fig. 2) and 0 otherwise. The municipality fixed effect γ_j cancels and ϵ_j is the error term.

For estimating the employment effects of which data are only available for one year, we adapt (1) to

[24] The earliest figures in which special cases appear are found in 1952. Back then, only 2% of all federal taxpayers were special cases in the canton of Grisons (Federal Tax Administration, 2023).

[25] The population data are aggregated to 2021 jurisdictions. Municipalities with access might have gone through more mergers over time and appear larger through that. Looking at municipalities that underwent no jurisdictional changes since 1960 reveals that municipalities with access were 23% larger in 1850 than municipalities without access.

[26] The rows Federal tax revenue per resident and income per taxpayer in Table 1 both represent the average per capita values in the average municipality.

Table 1 Summary statistics of the sample

Variable	All municipalities ($n = 227$)					AC ($n = 94$)	NAC ($n = 133$)	Diff
	Year	Mean	SD	Min	Max	Mean	Mean	
Geography								
Altitude (masl)	–	1105	275	751	1955	1179	1053	126***
Area (km^2)	–	57.84	64.38	1.17	438.75	73.43	46.82	26.61***
Distance to cantonal center (km)	–	49.19	26.77	4.75	137.76	51.91	47.28	4.63
Peak measure ($\frac{\#}{m^2} \cdot 1M$)	–	3.29	1.85	0.70	8.00	3.45	3.18	0.28
Lake distance (km)	–	14.19	8.58	0.01	43.00	14.36	14.07	0.30
Developable land measure (%)	–	16.55	24.98	0.00	99.51	9.12	21.80	− 12.68***
Sunshine exposure of dev. land (%)	–	37.48	19.85	0.00	78.92	38.48	36.78	1.69
Population								
Permanent residents	1850	871	909	0	5693	1052	743	309***
	1940	947	894	74	5070	1213	758	455***
	1980	933	917	30	5779	1253	707	546***
	2015	1162	1265	31	9948	1596	856	740***
Number of taxpayers	1947	148	152	3	1043	183	123	60***
	1980	378	413	13	3192	557	252	306***
	2015	553	674	20	6467	813	369	444***
Economic activity								
Employed (FTE)	2015	308	430	4	4138	492	178	315***
Federal tax revenue [1947 1000 CHF]	1947	6	9	0	84	8	5	3***
	1980	61	81	1	567	91	41	50***
	2015	157	378	1	5050	243	96	147***
Federal tax revenue per resident [1947 CHF]	1947	6	5	0	34	6	6	0
	1980	61	44	13	341	72	54	18***
	2015	114	120	14	957	136	99	37***
Taxable income [1947 1000 CHF]	1947	622	715	9	5662	783	508	275***
	1980	3183	3391	98	22,109	4433	2300	2133***
	2015	6375	8465	180	89,471	9007	4514	4493***
Income per taxpayer [1947 CHF]	1947	4064	1799	2455	29,709	4218	3956	262***
	1980	8437	1477	3819	12,367	8098	8677	− 579***
	2015	11,324	2109	5851	22,715	10,964	11,578	− 614***

The table shows summary statistics of geographic, demographic and economic data in our sample for all municipalities, municipalities with access (AC) (that gained access to at least one ski area between 1940 and 1982) and municipalities without access (NAC). The last column (Diff) indicates the differences in means of municipalities with and without access. The stars indicate the statistical significance of the difference from a two-sided t-test

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

$$y_j = \mu + \delta D_j + \nu_j, \tag{3}$$

where μ is the constant, δ is the coefficient of interest that recovers the association of ski area access to the outcome y_j and ν_j is the error term. This specification has no time difference that cancels time-constant characteristics across municipalities. Hence, the coefficient δ recovers differences in averages between municipalities with and without access.

Because ski areas do not appear randomly across space and we are not able to exploit quasi-experimental variation, the OLS estimates cannot be interpreted causally. However, as long as we can rule out reverse causality, the direction of the association is credible. In the next section, we argue against reverse causality and show in which direction the size of the OLS estimates is likely biased.

4.2 Exogeneity violations

Although we cannot identify variation that allows a causal interpretation of estimates from (2) and (3), we first argue why investments in ski areas cause population, income and tax revenue growth and not the other way around. Then, we show in what direction the OLS estimates are most likely biased.

Looking at the history of emerging tourism after the Second World War, we assume that local stakeholders seized the opportunity and invested in ski area construction. Presumably, tourism-related services were then established to meet the increasing demand. It is well documented how a surge in tourism demand causes increasing economic activities (see, e.g., Faber & Gaubert, 2019; Favero & Malisan, 2021; Nocito et al., 2021). At the same time, we rule out that a ski area was built as a consequence of an expected ex-post surge in population or an expected ex-post increase in financial means.

This would imply that individuals move to a municipality and raise local tax revenues before stakeholders build a ski area. We argue that such a series of events is implausible as individuals have no incentive to move to a relatively poor and rural municipality without new job offerings. Therefore, individuals move to a municipality after the decision to invest in a ski area has been made.[27] Moreover, this is plausible even if those municipalities tend to be larger and wealthier *ex-ante*. Instead of implying reverse causality, such a selection could be driven by differences in *ex-ante* growth rates which leads to a bias in OLS.[28]

Considering the permanent residents before the ski area access in Table 1, we see that a municipality about to be accessed was, on average, home to 42% more permanent residents in 1850 and 60% more permanent residents in 1940 compared to a municipality that was never accessed. This suggests that municipalities with an *ex-ante* larger population growth were more likely to be accessed by a ski area. Furthermore, differences in growth rates of other outcomes cannot be ruled out because we have no information prior to 1947. Altogether, it seems likely that municipalities with access to ski areas were on a positive economic growth path before the access. Not yet accessed municipalities with large economic potential facilitate investing in a ski area. As changes in economic potential are not only positively correlated to investing in a ski area but clearly to the outcomes themselves, selection leads to upward biased estimates in (2) and (3) for all observed outcomes.

A second concern is spillovers to neighboring municipalities. This refers to the problem when the effects disperse further in space than the municipality's own jurisdiction and contaminate the municipalities without access.[29] We exploit road distance rings between municipality centers and ski area access points in Online Appendix B.2 to show that capacity changes in ski areas affect outcomes within 2 km before 1980 but affect outcomes only above 2 km thereafter. At the same time, all variation from capacity changes within 2 km originates almost exclusively from municipalities with access to ski areas (i.e., almost all access points with road distances below 2 km lie within the borders of municipalities with access). Thus, we argue that spatial spillovers mainly appear after 1980. Presumably, a supply constraint in housing units (likely induced by the first federal Land Use Planning Act)[30] pushed residents increasingly to settle in neighboring municipalities because a commute to their working location became more attractive as rents and house prices rose.

Such spillover effects lead to downward biased estimates of all outcomes measured at the residence location of individuals.[31] These are population, income and tax revenue. Because employment is measured at the firm location, spillovers are only a concern regarding mobile tasks. Essentially, if a firm located in one jurisdiction can perform its task or value creation in another jurisdiction, for instance, in the construction sector. Notice that tourism-related services are mainly bound to their location.

Finally, there is no time difference in the cross-sectional specification (3) that cancels unobserved individual characteristics across municipalities. One way to address this is to balance geographic covariates in municipalities with and without access using propensity scores. However, as we select the sample based on geographic features such as altitude and the peak measure, the exogeneity assumption is violated for these covariates.[32] Most other geographic covariates are quite well balanced (as reported in Table 1), and therefore, using simple averages from (3) is more tractable here. The results from the inverse propensity score weighting (IPW) are in Online Appendix B.10 and yield quantitatively similar but less precise estimates as in the main specification.

[27] Notice that we explicitly exclude municipalities with access from the pioneering period where tourism emerged before the construction of the ski areas.

[28] Notice that we take care of time-constant *ex-ante* level differences by canceling the municipality fixed effects γ_j through the difference in (2). However, OLS is biased if those level differences are not stable over time.

[29] In the causal inference literature known as the stable unit treatment value assumption (e.g., Lechner, 2010).

[30] The act was adopted on January 1st 1980 (Federal Assembly of Switzerland, 1979). The act set the framework for cantonal and municipal policies. These led to restricted housing construction (Lendi, 2010) and possibly to increased competition among permanent residents with second home owners and seasonal workers in tourist municipalities.

[31] See Butts (2023) on how positive spatial spillovers to the control group attenuate treatment effects to zero in DiD setups.

[32] The altitude of the municipality center and the peak measure are post-access covariates in the sense that these measures serve as preconditions for building a ski area. Therefore, local stakeholders could anticipate the construction of a ski area by these alone which invokes further endogeneity (Lechner, 2010).

Table 2 Association of ski area access with population

Dependent variable:	**Log population**			**Log population**
Time difference $[t_1 - t_0]$:	**[1940 − 1900]**	**[1980 − 1940]**	**[2020 − 1980]**	**[(1980 − 1940) − (1940 − 1900)]**
	(1)	**(2)**	**(3)**	**(4)**
Ski area access	0.060†	0.153***	0.044	0.092†
	(0.034)	(0.046)	(0.042)	(0.049)
Intercept	0.046*	-0.120***	0.154***	-0.166***
	(0.020)	(0.028)	(0.033)	(0.028)
N units with access	94	94	94	94
N units w/o access	131	131	131	131
N overall	225	225	225	225
R^2	0.091	0.075	0.215	0.130

The table indicates OLS estimates of specification (2). In particular, the average association of access to a ski area between 1940 and 1982 with the population from $t_0 = 1900$ to $t_1 = 1940$ in column (1), from $t_0 = 1940$ to $t_1 = 1980$ in column (2), from $t_0 = 1980$ to $t_1 = 2020$ in column (3) and the change in population from the period of 1940 to 1980 compared to the period of 1900 to 1940 in column (4). The intercepts are equivalent to the population growth rates of the municipalities without ski area access. Standard errors are in parentheses and clustered at the municipality level

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5 Results

5.1 Population

In this section, we look at population changes in municipalities with ski area access. For this, we exploit data on permanent residents who live in a municipality at a given time. Table 2 shows point estimates of specification (2) at three different periods in columns (1) to (3) and an estimate of an additional difference in column (4).

The main result is indicated in column (2). Between 1940 and 1980, the population growth was, on average, 15.3 percentage points larger in municipalities with access to ski areas compared to municipalities without access. As shown by the intercept in column (2), municipalities without access were actually shrinking between 1940 and 1980 whereas municipalities with access were able to maintain their population.

However, growth in municipalities with access exceeded that of municipalities without access already before the ski area access period and thus indicates a positively biased estimate. Consider column (1) in Table 2: Between 1900 and 1940, the population growth rate was, on average, already 6.0 percentage points higher in municipalities with access to ski areas. Taking another difference between the ski area access period (1940–1980) and the period before the access (1900–1940) allows us to mitigate this violation and recover a more accurate estimate. In particular, we take the point estimate from column (2), subtract the point estimate from column (1) and test whether this difference is statistically different from zero.[33] The resulting estimate in column (4) reveals that the population change in municipalities with access to ski areas is 9.2 percentage points higher at a 10% statistical significance level. This effect rests on the assumption that the diverging population trend before the ski area access period would have remained constant in the absence of ski area access. It directly reduces the exogeneity violation invoked through a positive pre-trend in the population. It is thus a more credible estimate of what can be attributed to ski area access up to 1980. The positive bias in the DiD estimate increases the coefficient by two-thirds. We further investigate this pre-trend violation in Online Appendix B.3 using the whole panel with a dynamic DiD strategy (Callaway & Sant'Anna, 2021; de Chaisemartin & D'Haultfœuille, 2020, 2023) and find that never accessed municipalities were indeed on a lower growth path before the emergence of ski areas.

Looking at the expansion and concentration period (1980–2020) in column (3) shows no significant population effects for the period after the access period. Hence, the population differences leveled off after 1980 when municipalities gained no additional ski area access points. This aligns with the result that the population effects dispersed outward from municipalities with access after 1980 (see discussion in Sect. 4.2 and results in Online Appendix B.2). Presumably, the first Land Use Planning Act (Federal Assembly of Switzerland, 1979) adopted in 1980 restricted the housing supply while the ongoing increase in demand fueled competition

[33] In practice, we estimate a difference-in-difference specification $\Delta\Delta \ln y_j \equiv \Delta \ln y_{j,\text{post}} - \Delta \ln y_{j,\text{pre}} = \mu + \theta D_j + \zeta_j$, where $\Delta \ln y_{j,\text{post}}$ and $\Delta \ln y_{j,\text{pre}}$ correspond to (2) for the two time periods during and before the ski area access period, respectively. θ is the coefficient of interest, μ is the constant and ζ_j is the error term.

Table 3 Association of ski area access with employment shares in 2015

Dependent variable:	**Accommodation [%]**	**Gastronomy [%]**	**Retail [%]**	**Agriculture [%]**
	(1)	**(2)**	**(3)**	**(4)**
Ski area access	0.067***	0.025*	0.014*	– 0.128***
	(0.017)	(0.009)	(0.006)	(0.025)
Intercept	0.077***	0.055***	0.039***	0.296***
	(0.010)	(0.006)	(0.005)	(0.019)
N units with access	94	94	94	94
N units w/o access	133	133	133	133
N overall	227	227	227	227
R^2	0.066	0.032	0.018	0.096

The table shows OLS estimates of specification (3). In particular, the average association of access to a ski area between 1940 and 1982 with the share of accommodation employment (1), the share of gastronomy employment (2), the share of retail employment (3) and the share of agriculture employment (4) of all employed persons in full-time equivalents in 2015. The intercepts are equivalent to the employment shares of the respective sector without ski area access. Standard errors are in parentheses and clustered at the municipality level

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

among permanent residents, second home owners[34] and seasonal workers for ever scarcer housing units. The increased competition for affordable housing is likely a direct consequence of the tourism expansion and the overall population growth that comes with it. As a result, the ongoing ski area growth still attracts permanent residents, but the effects disperse in equal measure to municipalities with access and their neighbors after 1980.

Among other things, people were attracted to municipalities with access to ski areas because they provided new employment opportunities. That is why we continue to look at labor market outcomes.

5.2 Employment

So far, we observed that the municipalities with access to ski areas were more successful in maintaining their population during the ski area access period. To pin down in what sectors people work, we look at employment shares. As data are only available for the most recent period, we interpret the following labor market shifts as long-term equilibrium from three decades after the construction of the last ski areas.[35]

The results of the employment shares are given in Table 3. It presents OLS estimates of (3) using STATENT data across 2-digit ISIC industries in 2015. Column (1) shows that the share of full-time equivalents in municipalities with access to ski areas is, on average, 6.7 percentage points higher in the accommodation sector compared to municipalities without access with a share of 7.7%. Hence, municipalities with access employ almost twice the share of FTE in the accommodation sector. In addition, the gastronomy and retail sectors indicated in columns (2) and (3) have, on average, a 45% and 35% higher share of FTE in municipalities with access.

The higher employment shares in these three sectors come at the expense of a reduced employment share in agriculture. The FTE employment share in municipalities with access is, on average, 12.8 percentage points lower than in municipalities without access relative to an employment share of 29.6% (column (4) in Table 3). Therefore, the employment share in agriculture is reduced by 40% in municipalities with access. Further, we find no other changes in employment shares of other sectors that are statistically different from zero (see Online Appendix B.11).

The labor market shifts associated with ski area access affect not only where residents are employed but also how much they earn. As labor productivity in tourism-related services is and was higher than in agriculture (Federal Statistical Office, 2016; Rütter and Rütter-Fischbacher, 2016), some of the profits are passed down to the workers. Therefore, a municipality's employment composition alone increases incomes because of differences in labor productivity across sectors. We use employment data and local GDP estimates of the Alpine area from Rütter and Rütter-Fischbacher (2016) to study this employment composition channel. Assuming constant within-sector labor productivity across municipalities, we find that the employment composition alone contributes, on average,

[34] We find that the share of second home units among all housing units is 38% higher in municipalities with access to ski areas than in municipalities without access by 2021 (i.e., the share of second home units is 55% and 40% in municipalities with and without access, respectively) using publicly available data from the Federal Office for Spatial Development (2023).

[35] We show that the number of hotels, hotel beds and rooms remained constant since 1995 using hotel supply data of the FSO. Thus, we are confident that the presented labor market shifts not only appeared in the last thirty years but throughout the ski area access period. See Online Appendix B.8 for details.

Table 4 Association of ski area access with the tax base in 1980

Dependent variable:	Log taxable income	Log number of federal taxpayers		Log permanent residents
	(1)	(2) All	(3) Taxpaying residents	(4)
Ski area access	0.342***	0.439***	0.280***	0.136***
	(0.084)	(0.086)	(0.070)	(0.042)
Intercept	1.538***	0.755***	0.564***	− 0.117***
	(0.047)	(0.045)	(0.040)	(0.026)
N units with access	94	94	94	94
N units w/o access	133	133	133	133
N overall	227	227	227	227
R^2	0.888	0.719	0.657	0.079

The table shows OLS estimates of specification (2). In particular, the average association of access to a ski area between 1940 and 1982 with taxable income (1), the number of federal taxpayers (2) and the permanent residents (3). The baseline period is $t_0 = 1947$ and the second period is $t_1 = 1980$. Standard errors are in parentheses and clustered at the municipality level

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2.9% on differences in local GDP (see Online Appendix B.4 for details).

The overall association of ski area access with GDP might be larger since we expect within-sector productivity differences across municipalities and possible changes in labor volume. To incorporate the effects of these additional channels, we estimate changes in income growth using federal tax data.

5.3 Federal tax base

The federal tax data allow us to study the relation of ski area access to the taxable income generated in these municipalities.[36] We estimate the association using specification (2) for the years between 1947 and 1980. The results are in Table 4. Column (1) shows the changes associated with ski area access in aggregate taxable income. On average, aggregate income growth is 34.2 percentage points higher in municipalities with access compared to municipalities without access between 1947 and 1980. In column (2), we show that the number of federal taxpayers increased even more than the aggregate income. Between 1947 and 1980, growth in federal taxpayers was 43.9 percentage points higher in municipalities with access. Subtracting the special cases (mostly foreign second home owners, see Sect. 3.6) from all federal taxpayers in 1980, we get an estimate for the change in residential federal taxpayers' growth of 28 percentage points in column (3).

The permanent residents grew by 13.6 percentage points more on average (see column (4)), which partially explains changes in the tax base. Subtracting this from columns (1) to (3) in Table 4 leads to the residual change in income that is not explained by population changes. These remaining associations are 20.6, 30.3 and 14.4 percentage points for the changes in aggregate taxable income and the number of federal taxpayers (with and without special cases), respectively.[37] In the following, we argue what may drive these residual associations after accounting for population growth.

We explore two potential channels of the residual increase in the tax base: (1) Adjustments in labor volume at the intensive or extensive margin and (2) changes in labor productivity across and within sectors.

First, as a result of new job opportunities at ski areas, the labor volume might have increased at the extensive (more residents enter the labor force by finding employment) or intensive margin (the already employed work more hours and generate additional income). Comparing the employment rate across municipality types yields a relatively constant rate after the ski area access period (see Online Appendix B.9) and, therefore, suggests no substantial adjustments at the extensive margin.

Unlike the extensive margin, changes at the intensive margin of labor volume are likely: In a survey from 1998, 64% of Alpine farmers in Grisons and 51% in the Bernese Highlands state that they earn off-farm income from

[36] We assume that only a marginal share of residents in Alpine regions commuted across municipality borders to their workplace before 1980 due to no legal constraints in the housing supply, relatively large road distances, high commuting costs (see, e.g., Frey, 2010) and little evidence of spatial dispersion in Online Appendix B.2. Therefore, a majority of the taxable income collected in a municipality corresponds to what residents generate in that municipality.

[37] The estimate of ski area access with permanent residents is slightly smaller here than in Table 2 because the baseline period is at $t_0 = 1947$ instead of 1940.

winter tourism (Behringer et al., 2000).[38] This suggests that Alpine farming activities partly complement rather than substitute winter tourism in labor supply. Besides, the same could be true for other tasks obstructed by harsh winters in the mountains, such as craft work at construction sites. Hence, access to ski areas might have led to additional sources of income for local workers who were previously idle in winter. The additionally earned income lifts individuals' income above the minimum tax liability threshold and adds them to the taxpayers. Because there are no changes from the taxpayers at the extensive margin, we can infer that the large changes in the number of taxpaying residents must stem from a higher proportion of the population surpassing the minimum threshold of the federal tax (i.e., a per capita income increase) and, through that, increasing the tax base sizeable. See again Sect. 3.6.

The second channel that increases individual income is a change in labor productivity. We have seen in the previous section that at least 2.9% of the 2015 level difference in value added is due to the labor composition across sectors. However, we argue that the labor composition plays a smaller role in generating these differences than the within-sector productivity differences across municipalities. Certainly, a bulk of the observed income differences across municipality types can be explained by agglomeration economies that enhance local productivity through a variety of channels (see, e.g., Davis & Dingel, 2019; Duranton & Puga, 2004, Glaeser 2008). Looking at the accommodation sector supports the presence of agglomeration economies: By linking accommodation employment data to hotel supply data from the FSO, we find that by 2015 an average hotel contains 36% more rooms and employs 72% more FTE per room in municipalities with access compared to those without access. Therefore, hotels can pay more employees per available room, which might be related to a higher occupancy rate and, possibly, economies of scale.[39] Furthermore, having twice the number of hotels in the municipalities with access[40] might intensify horizontal competition or vertical product differentiation and, thereby, boost productivity (Barros and Alves, 2004; Zirulia, 2011).

The special cases reveal another interesting pattern. When looking at the mean differences between municipalities with and without access, we find that the former reported almost four times as many special cases as the latter in 1980. This confirms the high demand for second homes in municipalities with access to ski areas before the introduction of a federal law restricting foreigners from buying or building second homes (Federal Assembly of Switzerland, 1983).

When we look at how the tax base differences between Alpine municipality types have evolved since, we find that the three outcomes, taxable income, number of federal taxpayers and permanent residents, all remain at the level of 1980 (see Online Appendix B.6 for results up to 2015, we have no information on special cases after 1980). As discussed above and at length in Online Appendix B.2, the effects disperse to neighboring municipalities due to a shortfall of housing supply after 1980 but remain positive.

Altogether, we find that residents in municipalities with access to ski areas generated substantially higher incomes in the aggregate than in municipalities without access. Naturally, the gains in the tax base translate into higher tax revenues. Therefore, municipalities with access financially profit beyond having a larger and wealthier population. In the next section, we quantify these associations and discuss their implications for municipalities with access.

5.4 Federal tax revenue

We use federal tax data to quantify further the associations of ski area access and tax revenues. Gains in federal taxes likely go hand in hand with similar changes in municipal and cantonal taxes[41] and serve, thus, as a valid proxy to measure overall changes to tax revenues.

The OLS estimates of specification (2) for the federal income tax revenue are in Table 5. Column (1) shows that the federal income tax revenue growth between 1947 and 1980 was, on average, 51.6 percentage points higher in municipalities with access compared to municipalities without access. Column (2) indicates that the growth in the tax revenues per resident was, on average, 38.0 percentage points higher in municipalities with access across the same period. These substantial changes in tax revenues per resident further support the presence of

[38] On top of that, land use data (Federal Statistical Office, 2018 indicate that municipalities with access allocate much more land to Alpine farming than municipalities without access (see Online Appendix B.12).

[39] For a comprehensive overview of how hotels differ and are measurable in terms of productivity see Barros and Alves (2004).

[40] See Appenidx B.8 for details on how the number and size of hotels differ across municipalities.

[41] A regression of municipal tax multipliers on D_j and cantonal fixed effects for the year 2021 reveals that the municipal multiplier is, on average, 5 percentage points higher in municipalities with access (significant at the 5% level). We have no information on municipal tax multipliers further back than 2010. Still, this result suggests that municipal tax revenues might be slightly higher in municipalities with access than the federal tax revenues suggest. Furthermore, even if the local tax burden varies across municipalities, the effect on the growth rates of the federal income tax revenues is a good proxy for the effect on the growth rates of municipal income taxes as long as the progressivity difference between both does not change a lot over time.

Table 5 Association of ski area access with federal tax revenues in 1980

Dependent variable	Log federal tax revenue	Log federal tax revenue per resident
	(1)	**(2)**
Ski area access	0.516***	0.380***
	(0.115)	(0.102)
Intercept	2.173***	2.291***
	(0.065)	(0.058)
N units with access	94	94
N units w/o access	133	133
N overall	227	227
R^2	0.896	0.919

The table depicts OLS estimates of specification (2). In particular, the average association of access to a ski area between 1940 and 1982 with the federal tax revenues (1) and the federal tax revenues per resident (2). The baseline period is $t_0 = 1947$ and the second period is $t_1 = 1980$. Standard errors are in parentheses and clustered at the municipality level

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

individual income gains in municipalities with access to ski areas.

In line with the previous results, the tax revenue changes remain constant after 1980, suggesting that the ski area access period led to a onetime shift in tax revenue growth and did not induce a permanent faster growth path across municipalities (results across time are in Online Appendix B.7). However, as with the population and taxable incomes, we find that tax revenues disperse more in space after 1980 and, thus, affect municipalities with and without access in equal measure (see the results in Online Appendix B.2).

Our results on tax revenues suggest that municipalities with access became substantially wealthier during the ski area access period. Municipalities with access collected more taxes through the faster population growth and substantial increases in tax revenues per resident.

6 Conclusions

We show in the present work that the gain of access to ski areas during the skiing boom between the Second World War and 1980 is, on average, associated with 15.3 percentage points higher growth in permanent residents and is correlated to long-term employment shifts from agriculture (− 40%) to tourism-related service sectors such as accommodation (+ 90%), gastronomy (+ 45%) or retail (+ 35%). Gaining access to ski areas attracts residents and fosters structural changes in the economy. Municipalities with access grew stronger until 1980 before increasing competition for constrained housing units among residents, second homeowners and seasonal workers led to increased population dispersion to neighboring municipalities. Although we have limited information on second homeowners and seasonal workers, our results point in that direction. Exploring the competition for housing, its spatial dispersion and prices, and the resulting conflicts between these groups is a relevant topic for future research.

Furthermore, we show that the structural changes in the labor market associated with ski area access go hand in hand with 34.2 percentage points higher taxable income growth rate compared to municipalities without access on average. At the same time, the number of taxpayers extends by 43.9 percentage points faster. Accounting for population growth and special cases, the remaining residual raise in incomes emerges through two channels: First, for employed at occupations with weather-exposed tasks such as Alpine farming or work at the construction site, ski area access enables additional employment in the winter season. This enhances labor volume at the intensive margin and raises individual incomes above the minimum tax liability threshold. Secondly, municipalities with access offer more productive employment opportunities compared to municipalities without access. Their employees work in more productive sectors and the productivity of tourism-related services is also likely higher due to economies of scale and agglomeration economies.

We cannot quantify the relative contribution of each association to the overall income changes and which sectors drive the within-sector productivity differences the most. However, we argue that tourism-related services are certainly more productive using suggestive evidence from the hotel industry. It is conceivable that service industries unrelated to tourism also become more productive in municipalities connected to ski areas. Concentrating on such spillovers within the Swiss Alps, as discussed by Faber and Gaubert (2019), Favero and Malisan (2021) and Fan et al. (2022) in other contexts, is an interesting avenue for future research.

Finally, we find in municipalities with access to ski areas an average increase of 51.6 percentage points in overall tax revenue growth and a 38.0 percentage point increase in tax revenue growth per resident compared to municipalities without access. This alleviates the provision of enhanced local public goods for the municipal government and, more interestingly, enables the ski area operators to negotiate public funds to maintain the costly skiing infrastructure. Surely, the presence of positive spillovers of ski area access to local firms, employment and income can legitimize such an involvement (Lohmann and Crasselt, 2012). However, over time this leads to tight path dependencies between the local government and ski area operators (such local public financial involvement is documented in Derungs et al., 2019; Lengwiler & Bumann, 2018; Schuck & Heise, 2020).

In light of climate change, this poses a challenge for municipal governments that face the decision to support their ski area further, even though natural snow reliability is no longer given. It is thus a viable path for future research to zoom in on more recent developments and evaluate the efficacy and efficiency of local public policies.

The main limitation of our work is the non-random nature of how municipalities gain access to ski areas. This invokes potential biases that limit not the direction but the size of our estimates. Most estimates are upward biased because they are not solely attributable to the access to ski areas. Often, stakeholders in these municipalities decided to invest in a ski area precisely because the economic environment allowed them to do so. Taking an additional difference in population changes enabled us to lessen this selection bias. The point estimate remains sizable at 9.2 percentage points and is still 60% of the size of what we would have found if the data were restricted to a baseline period in 1940 instead of 1900. Considering these limitations, the sizes of our point estimates can, at best, be interpreted as upper bounds of causal effects and should, accordingly, be interpreted cautiously.

Abbreviations

AC	Municipality with ski area access
API	Application programming interface
ARE	Federal Office for Spatial Development
CHF	Swiss Franc
DiD	Difference-in-differences
ESPOP	Statistik des jährlichen Bevölkerungsstandes
FSO	Federal Statistical Office
FTA	Federal Tax Administration
FTE	Full-time equivalents
GDP	Gross domestic product
GEOSTAT	Center of competence for geoinformation and digital image processing
ISIC	International Standard Industrial Classification
LSAP	Lost ski area projects
NAC	Municipality with no ski area access
OLS	Ordinary least squares
STATENT	Statistik der Unternehmensstruktur
STATPOP	Population and Households Statistics
swisstopo	Federal Office of Topography
VZ	Census

Supplementary Information

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Supplementary Material 1

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Author contributions
All authors contributed to the concept, research questions, methodology and writing of the paper. PT collected and analyzed the data. All authors read and approved the final manuscript.

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Availability of data and materials
The data on ski areas that support the findings of this study are available from the owner of the platform *bergbahnen.org* but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. All data are, however, available from Pascal Troxler upon reasonable request and with permission of the owner of *bergbahnen.org*.

Declarations

Competing interests
PT and MR declare that they have no competing interests. MBT declares that she has a mandate on the board of directors in the firm Bergbahnen Destination Gstaad AG. However, the ski area in which this firm operates is not within the sample and does not benefit in any form from this research article.

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