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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 federal tax and population data to show how much ski area access benefits the municipality's economy. Evaluating difference-in-differences sheds light on how ski area access municipalities evolved economically compared to those without access. 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 access municipalities face once the decreasing snowpack forces a ski area to close.

Key words: Tourism development, regional economics, historical ski area data, climate change exposure

JEL classification: N74 ; N94 ; O18 ; R11 ; Z32

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1 Introduction

Around 70% of the Swiss landscape is covered by mountains that historically exacerbated economic growth due to the complex topography and harsh climatic conditions. Consequently, the mountain villages and towns experienced a 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?

Figure 1: The Swiss population development across different altitudes

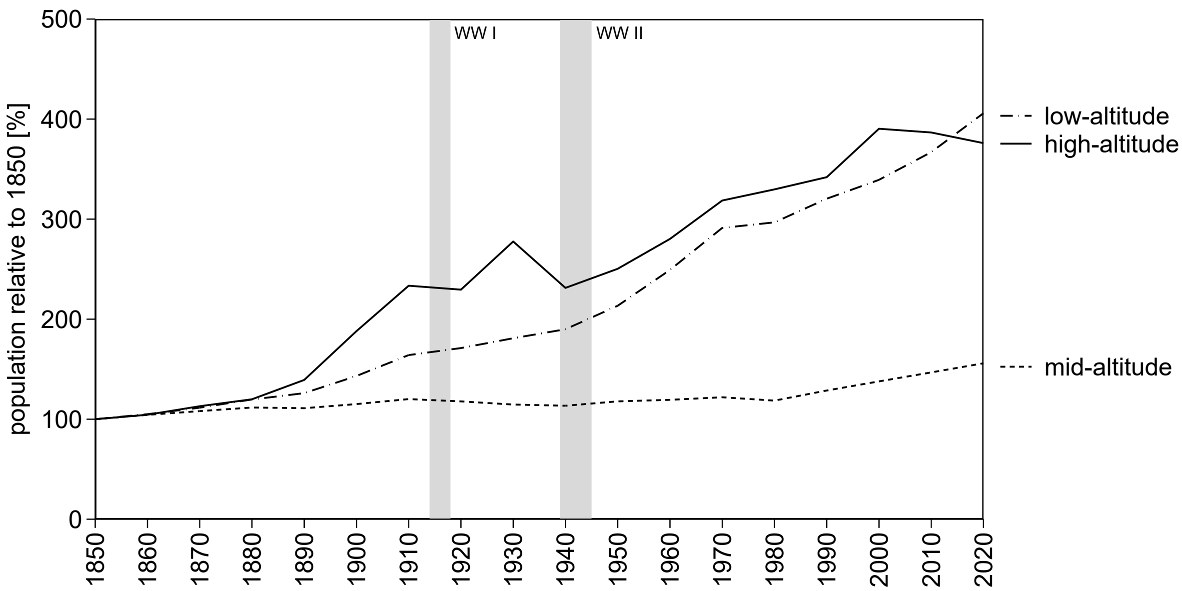


Figure Notes: The lines indicate aggregated population counts of Swiss municipalities below 750 m.a.s.l. (low-altitude), above 1500 m.a.s.l. (high-altitude) and at altitudes in between (mid-altitude) indexed to 100 in 1850.

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,

[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).

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 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 & 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 municipal-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 access municipalities have a 16% larger population 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% lower.

Furthermore, we find that the rise of tourism-related services translates into 41% higher taxable incomes at access municipalities persisting 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 income change is still at 15%. We argue that these changes originate primarily from individuals through (i) additional job opportunities that complement alpine farming and construction work and (ii) 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, either by 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 access municipalities 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, 66% higher federal tax revenues and 44% per resident. As the federal tax is a relatively constant share of cantonal and municipal taxes, 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 & Bürki, 2002; Gonseth, 2013; Gössling et al., 2012; Koenig & Abegg, 1997; Marty et al., 2017; Scott & Gössling, 2022; Steiger et al., 2015) and, with them, sales of tourism-related service industries (Lohmann & Crasselt, 2012; Wallimann, 2022). To understand the adverse effects of so-called Lost Ski Area Projects (LSAP) (Schuck & 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 & Bumann, 2018; Schuck & Heise, 2020). Accordingly, 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) find that financial involvement in tourism infrastructure correlates with the financial capacity of municipalities in the canton of Grisons. We contribute here by showing that ski area access municipalities 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 & Lin, 2012).[3]

Finally, we contribute to the literature on the emergence of tourism and its socio-economic impact. During the emergence of ski areas, the operator firm employs workers and the access municipalities require accommodations to host the expected tourist inflows (Wallimann,

[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]Bleakley and Lin (2012) document the ongoing importance of historical portage sites in the US, 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.

2022). Because tourists consume more than skiing, demand for complementary products and services such as ski schools, equipment rentals and sales rise (Lohmann & Crasselt, 2012). Research in various other contexts stresses that the emergence of tourism fostered economic growth (Favero & 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 & Gaubert, 2019; Fan et al., 2022; Spenceley & 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.

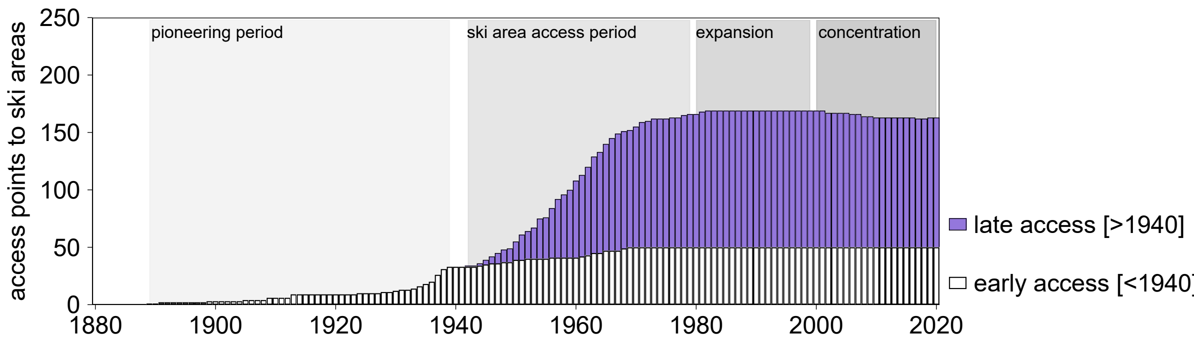
The paper continues as follows: Section 2 provides the history of ski area development. Section 3 describes the sample, various data sources and summary statistics. Section 4 leads through the empirical strategy and its identification which brings us to the results in Section 5. We conclude in Section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

2 History of Ski Area Development

The history of ski areas in Switzerland goes back to the 18th century. Thus, we split the history into four development periods based on historical accounts of Bärtschi (2015), Kyburz and Büchel (2018), Schuck and Heise (2020), and Tissot (2022). 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).[4]

Figure 2: Development of ski areas

(a) Access points across access timing



(b) Aggregate capacities and number of cableways

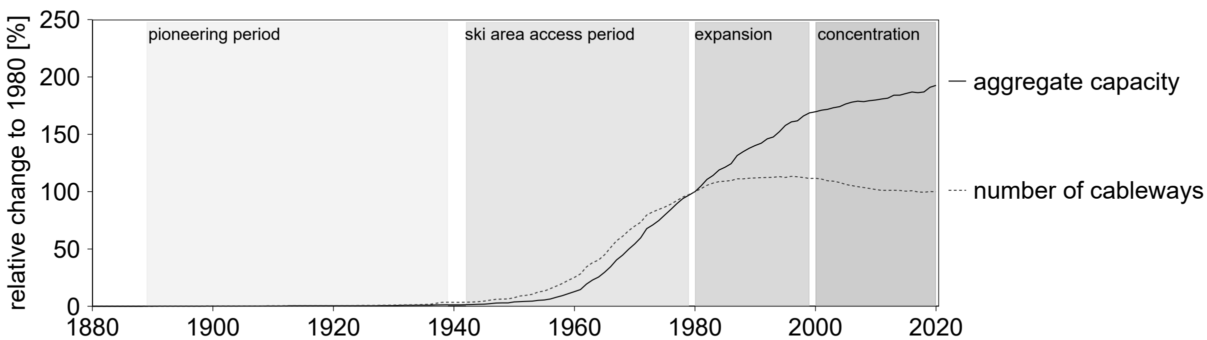


Figure Notes: The bars in panel (a) indicate Swiss ski area access point counts in municipalities with at least one access point before 1940 (white bars) and after 1940 (purple bars). The solid line in panel (b) shows the aggregate capacity of all lifts in all ski areas (measured as the number of persons lifted by 1 kilometer 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.

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 railway network, the birth of the modern Swiss democracy and road improvements removed some of the objections to tourism after 1850 (Kyburz & Büchel, 2018; Tissot, 2022).

[4]As our unit of interest is the municipality and ski areas can sometimes be accessed from multiple municipalities, having access to a ski area is the relevant measure to distinguish the municipalities. See Section 3.3 for further details.

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 appeal of 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 emerged in Switzerland that could be used for skiing (grey bars in Figure 2). However, skiing or let alone tourism was 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 latter ones were the majority until the 1930s. 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 all lift types that exist today (Bärtschi, 2015).

Consider panel (a) in Figure 2. It shows the total number of ski area access points at two municipality types. The white bars indicate access points that emerged in municipalities with a first access point during the pioneering period. The purple bars indicate those that emerged in municipalities during the next period, the ski area access period. Notice that some white-labeled points were accessed after 1940. These access points emerged in municipalities that already had access to another ski area before 1940.[5]

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, increasing wealth,[6] urbanization, commuting and car ownership, and reduced working hours[7] (Bandi Tanner & Müller, 2021). The rise in individual leisure opportunities was coupled with a surge in population.[8] Mass tourism emerged and a boom in skiing tourism occurred, fueling investments in cableways that were now primarily intended

[5] 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: In 1965 Madrisa, in 1969 Rinerhorn and in 1967 Pischa.

[6] Aggregate incomes almost quadrupled and more than doubled per capita in real terms between 1947 and 1980. The tax base grew from 1.2 Million to 2.5 Million over the same period.

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

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

to transport winter sports tourists uphill. The skiing infrastructure projects during this access period are the main focus of this paper. In panel (a) Figure 2, the newly developed ski area access points during the access period are depicted as purple bars. Approximately 100 new ski area access points were built between 1950 and 1970 alone and by 1980, the 191 ski areas[9] 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 & 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.[10] Consider again panel (b) in Figure 2 that shows how aggregate lift capacities (as the number of persons that are lifted by 1 kilometer per hour) and the number of cableways evolved relative to 1980.

The last period, the concentration period, is characterized by stagnating demand (Seilbahnen 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 & Bürki, 2002; Gonseth, 2013; Gössling et al., 2012; Koenig & Abegg, 1997; Marty et al., 2017; Scott & Gössling, 2022; Steiger et al., 2015) or operators were over-optimistic in their business cases but still found support by public funds (Schuck & Heise, 2020). On the demand side, exchange rate appreciation (Abrahamsen & Simmons-Süer, 2011; Plaz & Schmid, 2015), price reductions for air travel (Müller-Jentsch, 2017) and demographic challenges (Lütolf et al., 2020; Plaz & Schmid, 2015) all decrease skiing demand. Operators react by increasing competition over prices and infrastructure (Lütolf &

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

[10] 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 & 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 & Laesser, 2005; Derungs et al., 2019; Lengwiler & Bumann, 2018; Schuck & Heise, 2020)

Lengwiler, 2015; Lütolf et al., 2020; Wallimann, 2022) of which already large, higher-lying areas seem to gain the most (Schuck & 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 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). Municipality data covers municipality borders, the center coordinates and municipality mergers and splits back to 1960 (see 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 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 3-dimensional Euclidean distance and the number of peaks (see Appendix A.3.1 for an exact definition). Ultimately, this measure is a proxy of how deep a municipality lies in the Alps and, to some extent, how attractive the surrounding landscape is for skiing.

The white points in Figure 3 show all ski area access points in 1982 and the black lines indicate connected areas with access points in more than one municipality. The sample consists of municipalities indicated in purple and black. The former are municipalities that gained access to at least one ski area between 1940 and 1982. The latter are comparable Alpine municipalities that never had access to a ski area.

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

Figure 3: Municipality types and ski area access points in 1982

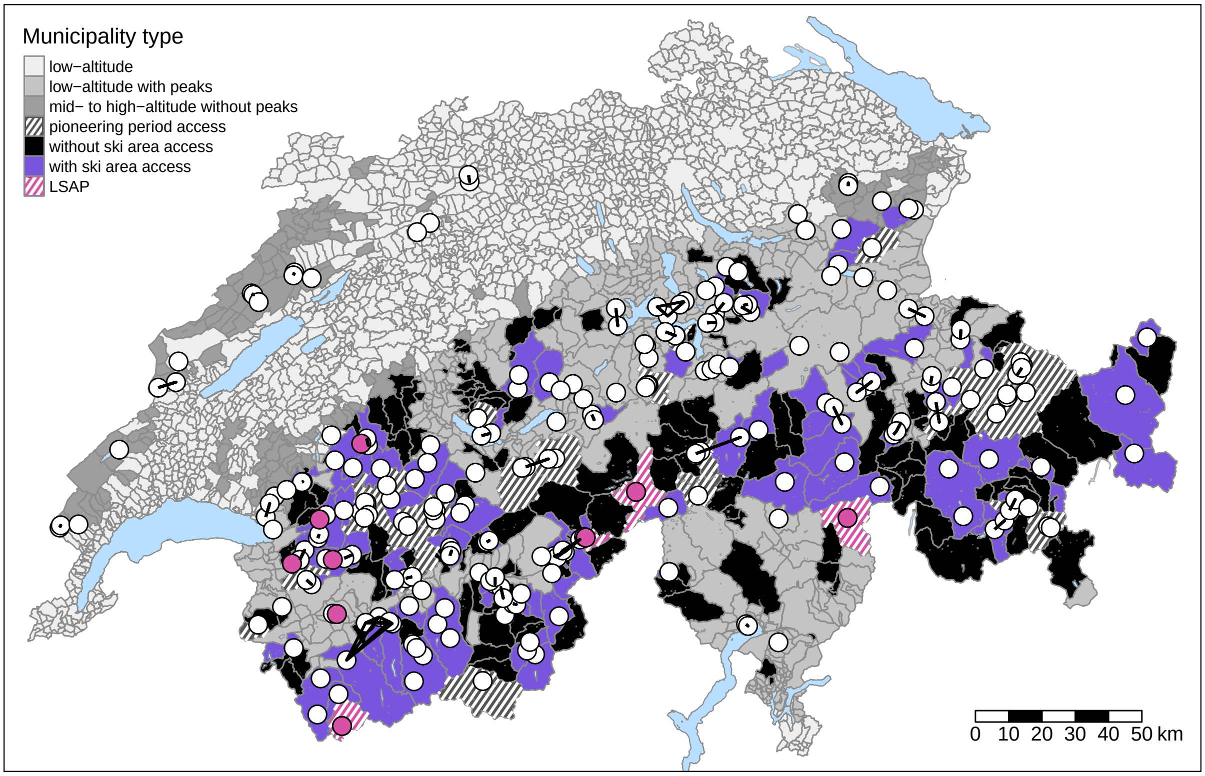


Figure Notes: The map indicates Swiss municipalities in 2021 jurisdictions separated into 7 categories based on altitude and whether a municipality is surrounded by sufficient peaks to be added to our sample. Dark shades (black and purple) and hatched areas indicate mountainous municipalities above 750 meters above sea level with alpine peaks nearby (see Appendix A.3.1 for the exact definition of that measurement). Black areas are municipalities without access, purple areas are access municipalities. Grey-hatched areas are excluded due to their tourism investments before 1940 (indicated as pioneering period access). Pink-hatched areas are excluded because these municipalities are connected to (later) lost ski area projects (pink points). Points indicate ski area access points in 1982 and the black lines show ski area connections across municipality borders.

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.[11]

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

[11] For example, Lucerne or municipalities in the Rhone Valley. Both were historically well connected by highways and early railways (Kyburz & Büchel, 2018) and are, thus, topographically and economically very distant from the municipalities we intend to study.

distant from the Alpine municipalities.

4. We exclude grey-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 pink-hatched municipalities connected to LSAP that were either unsustainable in their economic or climatic prospects (Schuck & 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.[12]

Our resulting sample consists of 227 municipalities in the Alpine region that are above 750m, are surrounded by alpine peaks, have no first-wave access and are connected to ski areas in operation. Of those, 94 are in the access group (purple in Figure 3) and 133 in the group without access (black in Figure 3). Access municipalities gained access to at least one ski area during the ski area access period between 1940 and 1982.

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.[13] 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 geo-locations 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 treatment 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 Appendix A.2.

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

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

We document nine LSAP in our data.[14] 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.

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).[15]

2. Lakes attract residents and tourists (Leuba, 2019; Waltert et al., 2011). Therefore, we compute the road distance to the next lake to measure this attractiveness with the Here API.

3. Using a 3-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-158m cells with an average slope below 15 degrees and within 200m 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 Appendix A.3.2.

4. We construct additionally a measure of sunshine exposure of that developable land. For each 158-by-158m cell, we compute the sunshine exposure on a typical winter day (when the sun is relatively low) and calculate the mean sunshine exposure among all developable land cells in a municipality. More sunshine would facilitate some agricultural activities and is also considered attractive for housing (Leuba, 2019). Details on how we construct this measure are in Appendix A.3.3.

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

[15] We compute the road distances with the Stata command *georoute* (Weber & Péclat, 2017). 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.

3.5 Population

The population data is from the FSO and includes Census (VZ), Population and Households Statistics (STATPOP) and Statistik des jährlichen Bevölkerungsstandes (ESPOP) data. 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 is available for every decade between 1850 and 2000 except 1890 and 1940, where the data is available for 1888 and 1941, respectively. These years are imputed using a rule by Kyburz and Büchel (2018). Additionally, the population counts in 1947 and 1975 are imputed to link them to income data. ESPOP data is from 1981 to 2010 and STATPOP from 2011 to today. The ESPOP data was harmonized with the VZ data at each decade. Further inconsistencies appear in 2011 from the change of ESPOP to STATPOP. The imputation and a complete description of the data sources are in 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 economic activity variables. 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 is available from the FSO statistic Statistik der Unternehmensstruktur (STATENT) on the 6-digit International Standard Industrial Classification (ISIC) level between 2011 and 2017. Within this short period, no substantial structural changes occurred (Bandi Tanner et al., 2021). For that reason, we neglect the time variation in that data. Moreover, to match the results with 2015 Gross Domestic Product (GDP) estimates, we use STATENT data only from that specific year.

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 is incomplete. Due to these gaps and the availability of GDP estimates in 2015, we mainly use data from 1980 and 2015[16] and build differences to 1947, the oldest data available.[17][18] Furthermore, we deflated all income data to 1947 CHF using

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

[17] We digitized the data between 1947 and 1958 and connected it to already digitized data from 1975 onward. See Appendix A.6 for details of this process.

[18] Notice that six municipalities in our sample already gained access to a ski area before 1947. These are

a historical consumer price index from the FSO to sustain comparability over time.

A limitation of the federal tax data is that it contains only 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. On top of that, the data contains so-called special cases. These contain 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).[19] We gathered the number of special cases in 1980 from the same data. However, we have no information about the incomes of individuals exempt from the tax (due to very low incomes) and from individuals who are taxed at the source (these are typically foreign seasonal workers). Increases in the number of taxpayers (without special cases) originate from either new residents moving to a municipality or more individuals surpassing the minimum federal tax threshold. Therefore, changes in that variable may reflect changes in individual incomes.

3.7 Summary Statistics

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

The municipalities with and without access are very similar in geographical features, except that the average access municipality 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.

Notice how the access status of a municipality points to large differences in population and economic activity, regardless of the year of measurement.

The population distribution is right-skewed, with a few large and many small municipalities such that the standard deviation exceeds the mean. The access municipalities already had,

Ormont-Dessus (1942), Château-d'Oex (1944), Flims and Tujetsch (1945), Beatenberg and Leukerbad (1946).

[19] Special cases also include taxpayers whose income substantially changed within the bi-annual tax period, 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).

Table 1: Summary statistics of the sample

	All municipalities ($n = 227$)					AC ($n = 94$)	NAC ($n = 133$)	
Variable	Year	Mean	SD	Min	Max	Mean	Mean	Diff
Geography								
Altitude [masl]	-	1,105	275	751	1,955	1,179	1,053	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 [%]	-	42.46	10.42	8.61	81.45	42.67	42.30	0.37
Population								
Permanent Residents	1850	871	909	0	5,693	1,052	743	309***
	1940	947	894	74	5,070	1,213	758	455***
	1980	933	917	30	5,779	1,253	707	546***
	2015	1,162	1,265	31	9,948	1,596	856	740***
Number of taxpayers	1947	148	152	3	1,043	183	123	60***
	1980	378	413	13	3,192	557	252	306***
	2015	553	674	20	6,467	813	369	444***
Economic activity								
Employed [FTE]	2015	308	430	4	4,138	492	178	315***
Federal tax revenue [1947 1,000 CHF]	1947	6	9	0	84	8	5	3***
	1980	61	81	1	567	91	41	50***
	2015	157	378	1	5,050	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 1,000 CHF]	1947	622	715	9	5,662	783	508	275***
	1980	3,183	3,391	98	22,109	4,433	2,300	2,133***
	2015	6,375	8,465	180	89,471	9,007	4,514	4,493***
Income per taxpayer [1947 CHF]	1947	4,064	1,799	2,455	29,709	4,218	3,956	262***
	1980	8,437	1,477	3,819	12,367	8,098	8,677	-579***
	2015	11,324	2,109	5,851	22,715	10,964	11,578	-614***

Table Notes: The table shows summary statistics of geographic, demographic and economic data in our sample for all municipalities, access municipalities (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.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

on average, 50% more permanent residents in 1850 and grew faster than those without access.[20] 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

[20]The population data is aggregated to 2021 jurisdictions. Access municipalities 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 access municipalities remained 30% larger in 1850 than municipalities without access.

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 access municipalities 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 municipalities generated only 6 CHF federal income tax revenue per resident on average. By 2015, per capita incomes 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 Figure 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 is only available for one year, we adapt (1) to

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

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.[21] 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.[22]

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 access municipalities 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 access municipality's own jurisdiction and contaminate the municipalities without access.[23] We exploit road distance rings between municipality centers and ski area access points in Appendix B.2 to show that capacity changes in ski areas affect outcomes within 2km before 1980 but affect outcomes only above 2km thereafter. At the same time, all variation from capacity changes within 2km originates almost exclusively from access municipalities (i.e., almost all access points with road distances below 2km lie within the access municipalities' borders). 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)[24] 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

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

[22] 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.

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

[24] 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.

residence location of individuals.[25] 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.[26] 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 Appendix B.8 and yield quantitatively similar but less precise estimates as in the main specification.

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). By 1980, the population was, on average, 16% (the point estimate of 0.153 shown in Table 2 means a by 16% higher population expressed in exact percentages)[27] larger in access municipalities.[28]

However, access municipalities' growth exceeded that of municipalities without access already before the ski area access period and thus indicates a positively biased estimate. Consider

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

[26] The altitude of the municipality center and the peak measure are post-access covariates in the sense that these measures serve as pre-conditions 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).

[27] Henceforth, we express all point estimates as exact percentages. Exact percentage changes are obtained by $e^{\hat{\beta}} - 1 = e^{\ln y^1 - \ln y^0} - 1 = e^{\ln y^1 / y^0} - 1 = \frac{y^1 - y^0}{y^0} = \%\Delta y$ where superscripts 1 and 0 of outcomes indicate municipalities with and without access, respectively.

[28] Notice that municipalities without access were actually shrinking between 1940 and 1980 whereas access municipalities were able to maintain their population (see Table 1).

Table 2: The 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]	$\big[(1980-1940)-(1940-1900)\big]$
	(1)	(2)	(3)	(4)
Ski area access	$0.060^{\dagger}$	0.153^{***}	0.044	$0.092^{\dagger}$
	(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

Table Notes: 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 changes of the municipalities without ski area access. Standard errors are in parentheses and clustered at the municipality level.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

column (1) in Table 2: By 1940, the population was, on average, already 6% larger in access municipalities. 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.[29] The resulting estimate reveals that the population change at access municipalities is 10% 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 60%.

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

[29] In practice, we estimate a Difference-in-differnce-in-differences specification $\Delta\Delta \ln y_j \equiv \Delta \ln y_{j,post} - \Delta \ln y_{j,pre} = \mu + \theta D_j + \zeta_j$, where $\Delta \ln y_{j,post}$ and $\Delta \ln y_{j,pre}$ 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.

points. This aligns with the result that the population effects dispersed outward from access municipalities after 1980 (see discussion in Section 4.2 and results in 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 fuelled competition among permanent residents, second home owners[30] 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 access and neighboring municipalities after 1980.

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

5.2 Employment

So far, we observed that the access municipalities raised their population during the ski area access period. To pin down in what sectors people work, we look at employment shares. As data is 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.[31]

The results of the employment shares are 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 access municipalities is, on average, 6.7 percentage points higher in the accommodation sector compared to municipalities without access with a share of 7.7%. Hence, access municipalities 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 access municipalities.

The higher employment shares in these three sectors come at the expense of a reduced employment share in agriculture. The FTE employment share in access municipalities is, on average, 12.8 percentage points lower than in municipalities without access relative to an

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

[31] 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 Appendix B.6 for details.

Table 3: The association of ski area access with employment shares in 2015

Dependent variable:	Accommodation [%] (1)	Gastronomy [%] (2)	Retail [%] (3)	Agriculture [%] (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

Table Notes: 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.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

employment share of 29.6% (column (4) in Table 3). Therefore, the employment share in agriculture is reduced by 40% in access municipalities. Further, we find no other changes in employment shares of other sectors that are statistically different from zero (see Appendix B.9).

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 & 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, 2.9% on differences in local GDP (see Appendix B.3 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 using federal tax data.

5.3 Federal Tax Base

The federal tax data allows us to study the relation of ski area access to the taxable income generated in these municipalities. 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 incomes are 41% higher in access municipalities by 1980. In column (2), we show that the number of federal taxpayers increased even more than the aggregate income. By 1980, 55% more persons pay taxes in access municipalities. Subtracting the special cases (mostly foreign second home owners, see Section 3.6) from all federal taxpayers in 1980, we get an estimate for the residential federal taxpayers (assuming little or no special cases in 1947) of 32% in column (3).

Table 4: The 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) Residents only	(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

Table Notes: 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.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Because in access municipalities live 15% more permanent residents (column (4)) on average, the remaining association of 23%, 35% and 15% are the changes in aggregate taxable incomes and the number of federal taxpayers that cannot be explained by population growth.[32] Besides, at least another 2.9% of the difference is due to the labor composition across sectors (as shown in the previous section). In the following, we argue what may drive these residual

[32] These figures are recovered by subtracting the coefficients of ski area access in column (4) from column (1), (2) and (3), and calculating the exact percentage effect $e^{\hat{\beta}} - 1$. Notice that the association 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.

associations after accounting for population growth and employment composition.

We explore two potential channels of the residual increase in the tax base: (i) Adjustments in labor volume at the intensive or extensive margin and (ii) changes in within-sector labor productivity differences across municipalities.

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 Appendix B.7) 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 winter tourism (Behringer et al., 2000).[33] 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 would lift individuals' income above the minimum tax liability threshold and add them to the taxpayers.[34]

The second channel that increases individual income is raising labor productivity within sectors but 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 access municipalities. Therefore, hotels can pay more employees per available room, which might be related to a higher occupancy rate and, possibly, economies

[33] On top of that, land use data indicate that access municipalities allocate much more land to alpine farming than municipalities without access (see Appendix B.10).

[34] Because there are no changes from the taxpayers at the extensive margin, we can infer that the large changes in the number of residential federal taxpayers must stem from a higher proportion of the population surpassing the minimum threshold of the federal tax and, through that, increasing the tax base sizeable. See Section 3.6.

of scale.[35] Furthermore, having twice the number of hotels in the access municipalities[36] might intensify horizontal competition or vertical product differentiation and, thereby, boost productivity (Barros & Alves, 2004; Zirulia, 2011).

The special cases reveal another interesting pattern. When looking at the mean differences between access and non-access municipalities, we find that access municipalities reported almost four times as many special cases as non-access municipalities in 1980. This confirms the high demand for second homes in access municipalities 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 have evolved, we find that the three outcomes, taxable income, number of federal taxpayers and permanent residents, all remain at the level of 1980 (see Appendix B.4 for the results up to 2015, we have no information on special cases after 1980). As discussed above and at length in 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, access municipalities financially profit beyond having a larger and wealthier population. In the next section, we quantify these associations and discuss their implications for access municipalities.

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[37] 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 federal tax revenues up to 1980 were, on average, 66% higher in

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

[36] See Appenidx B.6 for details on how the number and size of hotels differ across municipalities.

[37] 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 access municipalities (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 access municipalities than the federal tax revenues suggest.

access municipalities. Column (2) indicates that the federal tax revenues per resident were, on average, 44% higher in access municipalities by 1980. These substantial differences in tax revenues per resident further support the presence of individual income gains in access municipalities.

Table 5: The association of ski area access with federal tax revenues in 1980

Dependent variable:	Log federal tax revenue (1)	Log federal tax revenue per resident (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

Table Notes: 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.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In line with the previous results, the tax revenue changes remain constant after 1980, suggesting that the ski area access period led to a one-time shift in tax revenues and did not induce a permanent faster growth path across municipalities (results across time are in Appendix B.5). However, as with the population and taxable incomes, we find that tax revenues disperse more in space after 1980 and, thus, affect access and non-access municipalities in equal measure (see the results in Appendix B.2).

Our results on tax revenues suggest that access municipalities became substantially wealthier during the ski area access period. Access municipalities 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 16% more permanent residents and 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. Access municipalities 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 41% higher taxable incomes on average. At the same time, the number of taxpayers extends by 55%. 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, access municipalities offer more productive employment opportunities. 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), Fan et al. (2022), and Favero and Malisan (2021) in other contexts, is an interesting avenue for future research.

Finally, we find in access municipalities an average increase of 66% in overall tax revenues and a 44% increase in tax revenues per resident. 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 externalities of ski area access to local firms, employment and income can legitimize such an involvement (Lohmann & 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 our data. 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 10% and is still 60% of the size of what we would have found, was the data 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.

7 Literature

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Appendix

A Data Processing

A.1 Municipality Data

The data covers municipality borders, the center coordinates that remained arguably at the same spot over the past 170 years[38] and the complete list of all municipality mergers and splits between 1960 and 2021. We aggregate all data to the 2021 jurisdictions because in the past most municipalities rather merged than split up. Historical data based on old jurisdiction is easily merged to the 2021 borders. However, recent data cannot be split into the historical jurisdictions from 1960.

A.2 Ski Area Data

We use the dataset provided by *bergbahnen.org*, which consists of all ever-built cableway lifts grouped into pre-defined areas. The goal is to match these data with Swiss municipalities as they exist at the beginning of 2021. First, we want these data grouped at municipality-area-year cells and later at municipality-year cells to match all other data.

Cableway data consists of roughly 500 areas that require matching to the adjoining municipalities, our unit of interest. The following steps have been implemented to match ski areas to municipalities coherently. A year in the data is always considered the initial operation year of a lift. For example, a lift built in the summer of 2013 operates normally from the winter of 2013/14 onwards.

First, we manually add missing lifts or data. For example, all racket railways are missing even though they were crucial to the emergence of ski areas, especially in the early 20th century. Second, we detect access lifts from which ski areas are entered. Some areas have multiple access lifts from separate municipalities and others are connected to more than one ski area. Third, we define ski areas from the cableways clusters and drop all clusters not in our definition. Fourth, we adapt ski area mergers manually. That is, we split areas in those years where they are considered one area (as defined by *bergbahnen.org*) when they were two areas. Or, we merge areas considered to be two areas (as defined by *bergbahnen.org*) when they are one area for the years in question.

[38] In the data description, it is noted that the center was often manually chosen at the church or the central village square.

A.2.1 Missing Data

Some lift observations have missings in z-coordinates. They are recovered by matching the 2-dimensional latitude-longitude coordinates to a 3-dimensional shapefile of Switzerland from the swisstopo.

The *bergbahnen.org* data does not cover rack railways. Thus, I use information from historical accounts (Bärtschi, 2015; Frey & Schiedt, n.d.-b) and wikipedia to add missing railway stations that were explicitly linked to winter sports. Note that access points are defined at the train station of the last municipality before the mountaintop. For example, the train from Blonay to Pleiades starts actually in Montreux. But because the distance from Montreux to Blonay can be seen as road or train distance to that train station, we only count Blonay, the last municipality, before reaching the top. When two municipalities from opposing mountainsides reach the top with different trains, both are counted as access points (e.g., Rigi).

Table 6: Racket railways in Switzerland that are connected to a ski area

Name	Source & Info	Access points	Coordinates (lat/lon)	Operates in Winter since
Wengernalpbahn	Bärtschi (2015) de.wikipedia.org	Wengen Grindelwald	46.60507/7.92087 46.62456/8.03266	1909
Gornergratbahn	Bärtschi (2015) de.wikipedia.org	Zermatt	46.02381/7.74929	1928
Furka-Oberalp-Bahn	Bärtschi (2015) de.wikipedia.org	Sedrun Andermatt	46.68112/8.76960 46.63696/8.59331	1945
Blonay - Les Pléiades	Frey and Schiedt (n.d.-b) fr.wikipedia.org	Blonay	46.46584/6.89578	1954
Rochers de Naye	Bärtschi (2015) de.wikipedia.org	Glion	46.43192/6.92420	1957
Bex-Villars-Bretaye	Frey and Schiedt (n.d.-a) de.wikipedia.org	Villars	46.29580/7.05652	1937
Rigi	Bärtschi (2015) rigi.ch	Vitznau Arth	47.00901/8.48274 47.04895/8.54968	1905

A.2.2 Detection of Access Lifts

First, the data are cleaned and expanded to the operation years of each lift to get lift-area-year cells. Next, access points of the areas are searched. These points are crucial: Access points should be matched to municipalities in some form of spatial aggregation (e.g. inverse distance weighting) such that investments in the lift capacity of an area connected to that access can be considered a treatment to the surrounding municipality. Some lifts might not lie in the municipality that has access to these lifts. Thus, allocating the areas to their corresponding municipalities via access points is crucial.

To calculate the access points to the municipalities, we first match all valley stations to municipality polygons of 2021 jurisdictions from the FSO. Then, we create three potential indicators of area access for each valley station of all lifts:

1. All valley stations that lie at a maximum 500m above or below the municipality center (the center where the lift lies)
2. The lowest-lying valley station within each area-year cell
3. The lowest-lying valley station within each area-municipality-year cell

The second indicator is considered always an area entry. We require the third indicator because an area might have access to more than one municipality. Yet, the third indicator is not always necessarily a true access point. It could be that a municipality contains a lift on top of a mountain within its borders but does not have direct access to that area. Thus, a true access point must also satisfy the first indicator.

Finally, an access point is defined as the lowest-lying station for each area in each year (indicator 2) or it is at the same time the lowest-lying station for each area-municipality-year cell (indicator 3) and is not too far from the municipality center in vertical distance (indicator 2).

Access lifts from multiple municipalities to an area

The goal is to aggregate the data into year-municipality cells. Thus, if an area is accessed by more than one municipality, we duplicate the observations of the lifts in each year-municipality-area cell such that when we collapse to the area level (instead of the lift level) of that cell, both municipalities have access to the same summed up lift characteristics (such as capacities and numbers of lifts) in the same year. In practice, we expand all lift observations of an area on the number of access points, allocate all lift duplicates to a new access point municipality and collapse the data again by year-municipality-area cells.

This procedure leads to the intended cells at the area level because there is only one access point per year-municipality-area cell (as defined above). An area accessed by two municipalities is then aggregated into two observations with the same characteristics per year. When only one access point to the area initially exists, only one observation exists in the data.

Multiple access lifts in one municipality to multiple areas
As we collapse the data to year-municipality-area cells, a municipality with access to, for instance, two areas mechanically has two observations per year. One for each area. This gives a relatively simple solution when data are later collapsed into year-municipality cells. The area characteristics (such as capacities and the number of lifts) are summed across areas to the municipalities.

A.2.3 Ski Area Definition

We define a ski area as a cluster of cableways consisting, on average, of at least two lifts throughout its existence. That means we count the number of lifts per year and average this value across the existence of the cluster. All areas with an average ≥ 2 are kept in the data, the rest is dropped. Doing this allows us to exclude urban cableways, excursion lifts and small community-run village lifts.

A.2.4 Ski Area Mergers

In some minor instances, ski areas merged over the years. In such a year, a municipality might suddenly get access to twice the lift capacity. We keep the areas at their historical access. Thus, a not yet merged area shows up as two before the merge and has an additional area ID. As soon as they merge they will show up as one individual area with one of the succeeding area's IDs.

A.3 Geographical Data

A.3.1 Peak Measure

Using swisstopo data of map names allows us to identify alpine peaks. All main peaks and alpine peaks (called "Hauptgipfel" and "Alpiner Gipfel" in the swisstopo-3D-Names) are first cleaned from duplicates (some peaks appear in two or more languages).

The peaks are then assigned to the municipalities in a gravity-based measure that weighs their altitude and their closeness to the peak (see Gutiérrez et al., 2010 chapter 2.2 for a list of literature that uses these kinds of measures in the transportation literature). The altitude mass is calculated by simply dividing each peak by the altitude of the lowest peak (=1607m above sea level) to get altitude mass m_p^{alt}. Then a mass of one is assigned to the smallest peak and a mass above one to all higher peaks proportionally to their altitude.

In the next step, we link each peak ($P = 2,954$) to all municipalities ($J = 2,175$) and calculate the three-dimensional Euclidean distance [in meters] of each peak to all municipality centers. From this we divide each peak's mass by the inverse squared distance and sum those values up for each municipality:

$$peak_j = \sum_{p=1}^{P} \frac{m_p^a}{(d_{pj}^{E3})^2} \tag{4}$$

where *peak* is the final measure, j is a municipality, p is an individual peak, d_{pj}^{E3} the three-dimensional Euclidean distance between peak coordinates $p^{\otimes}$ and municipality center coordinates $j^{\otimes}$. We use a squared inverse distance weight to overweight short distances compared to long distances. The reason for this is twofold.

First, the closer one gets to a peak the harder and slower it gets to reach the top[39]. Thus, being able to start an expedition (in the 19th century) or reach the peak by cableways (in more recent times) is simpler the closer one can lodge overnight (in the 3-dimensional distance).

Second, as Switzerland is relatively small, we would overweight central municipalities to border municipalities when distances were weighted inversely linear. Additionally, the measure is scaled up by 1'000'000 to allow for a simple interpretation. The peak measure has the following intuition: A peak measure of 1 means that there is exactly one peak with an altitude of 1607m and 1km distance to the municipality center. A peak measure of 2 could mean that there is one high peak of exactly 3214m altitude at 1km distance, two low peaks at 1km distance, or two high peaks at $\sqrt{2km}$ distance and so on.

A.3.2 Developable Land Measure

To construct the developable land measure, we first aggregate the shapefile from swisstopo to a resolution of 158-by-158m to facilitate computation. Then, we remove all pixels with an average slope above 15 degrees and an altitude above 2000 m.a.s.l. because this terrain is either too steep or too high (no municipality centers in Switzerland lie above 1900 m.a.s.l.) for large-scale construction of housing or industrial buildings.

Next, we match the data with municipality polygons from swisstopo and remove all pixels on lakes. On top of that, we remove pixels that are further than 200m in altitude apart from the municipality center. In the 19th century, developing land far from the municipality center

[39]Take the access to the Matterhorn as an example where the journey starts in the large Rhone valley of Wallis with flat terrain where moving through the valley goes unhindered. After that one enters the narrower Matter valley that becomes narrower and more difficult, the closer one gets to Zermatt. After passing through Zermatt, the hike begins and the closer one gets to the top, the more it becomes a difficult climb.

(without good roads and barely any racket railways/cableways) would greatly complicate things.

Finally, we compute all pixels that fulfill the above conditions, count them, and divide them by the total number of pixels within a municipality's jurisdiction. The resulting measure is then the share of developable land within each municipality.

A.3.3 Sunshine Exposure of Developable Land

For this measure, we take the same pixels with a resolution of 158-by-158m from the developable land measure and compute the exposure to the sun on a winter day. For each pixel the sun exposure is computed using the rayshader package in R (Morgan-Wall, 2023) with a sunshine angle of 195.03° (sunshine from south-south-west) and sunshine altitude of 18.53 which is where the sun lies at the winter solstice on 21st December at 13.25 p.m.[40] in Andermatt (pretty much the center of the Swiss Alps).

The sunshine exposure is a variable scaled between 0 (no exposure) and 1 (maximum exposure) assigned to each developable land pixel on the map. Then, we take the average of all pixel values within a municipality to get the average sunshine exposure of the developable land.

A.4 Population Data

A.4.1 Data Sources

The FSO describes the three data sources as follows (rough translation from information gathered at Bundesamt für Statistik (BFS) (2023), Federal Statistical Office (2023c) and Federal Statistical Office (2023a).

ESPOP
ESPOP was a statistic based on the statistics of natural population movements (BEVNAT), the statistics of the foreign resident population (PETRA) and the migration statistics of the Swiss resident population and was corrected for the population census of 1990 and 2000 (VZ) (Bundesamt für Statistik (BFS), 2023).

STATPOP
STATPOP takes stock and movement data from the federal government's registers of persons

[40]Taking high-frequency temperature data (per 10 minutes) from three weather stations (in Montana, Andermatt and Davos) for 6 years and joining this with sunshine data, we find that the maximal temperature throughout a sunny day (above 80% relative sunshine duration) in winter is on average at 13.25p.m

and the harmonized population registers of the communes and cantons and is thus based on a different production method than ESPOP (Federal Statistical Office, 2023c).

VZ

From 1850 to 2000, a census was carried out every 10 years by questionnaire among the entire population of Switzerland. The results allowed statements about the demographic, spatial, social and economic development of the country (Federal Statistical Office, 2023a).

General Information

The population stocks as of December 31 of a calendar year and January 1 of the following calendar year are not identical in the following cases: (1) adjustment of the stock data to the VZ (1990/91 or 2000/01); (2) changeover from ESPOP to STATPOP (2010/11); (3) territorial status changes at the canton, district or commune level (various years).

The reference population of the demographic balance is the "permanent resident population", which until 2010 included all Swiss nationals with a main residence in Switzerland and all foreign nationals with a residence permit for at least 12 months. With the introduction of STATPOP, the reference population was redefined. Since 1.1.2011, it includes persons in the asylum process with a total stay of at least 12 months. (Bundesamt für Statistik (BFS), 2023; Federal Statistical Office, 2023a, 2023c)

A.4.2 Imputation

The population data was gathered in 1888 instead of 1890 and 1941 instead of 1940. As we require the population counts at the exact decade, we impute the two missing years from three population counts each (Kyburz & Büchel, 2018). To impute the population count in 1890 we use

$$pgr_{80,88} = \left(\frac{pop_{88}}{pop_{80}}\right)^{1/8} \tag{5}$$

$$pgr_{88,00} = \left(\frac{pop_{00}}{pop_{88}}\right)^{1/12} \tag{6}$$

$$pop_{90} = \frac{1}{2}pop_{88} \cdot (pgr_{80,88})^2 + \frac{1}{2}pop_{88} \cdot (pgr_{88,00})^2. \tag{7}$$

To impute the population count in 1940 we use

$$pgr_{30,41} = \left(\frac{pop_{41}}{pop_{30}}\right)^{1/11} \tag{8}$$

$$pgr_{41,50} = \left(\frac{pop_{50}}{pop_{41}}\right)^{1/9} \tag{9}$$

$$pop_{40} = \frac{1}{2}pop_{41} \cdot (pgr_{30,41})^{-1} + \frac{1}{2}pop_{41} \cdot (pgr_{41,50})^{-1}. \tag{10}$$

To impute the population count in 1947 we use

$$pgr_{41,50} = \left(\frac{pop_{50}}{pop_{41}}\right)^{1/9} \tag{11}$$

$$pop_{47} = pop_{41} \cdot (pgr_{41,50})^{6}. \tag{12}$$

A.5 Employment Data

The employment rate for the three sectors is publicly available data from the federal population census Federal Statistical Office (2023a) and is based on surveys on the employment status and type of work of permanent residents in a municipality.

The granular employment data for 6-digit ISIC codes is provided by the FSO. All Swiss employees who are subject to social insurance are gathered in the data. This includes self-employed and employed individuals who earn at least 2'300 CHF per year. The labor volume of all full- and part-time workers is then translated to the FTE for each firm in each municipality. Further details on the data can be found in Federal Statistical Office (2023d).

We aggregate this data to the municipality level (2021 jurisdictions) and compute the shares of employed across sectors within municipalities for the relevant ISIC codes

A.6 Tax Data

The FTA data from 1973 and later are aggregated to municipalities and are publicly available bi-annually. Older bi-annual municipality-level tax data from 1947 to 1958 are mostly only as counts of tax subjects in income brackets available and only as scans in PDF format. The exception is the 1947/1948 data, where bracket counts and the overall income of the tax base are available. See Federal Tax Administration (2023) for details and the data.

We digitized the historical tax documents from 1947 to 1958 and merged the data to 2021 municipal jurisdictions. In the end, we only use the 1947/48 data where all data (counts of tax base and the tax subjects' aggregate income) is available for our study area.

Individuals are exempt from taxes if their bi-annual average yearly taxable income is very low. Also, the allowed tax deductions that lead to the taxable income changed over the years. An overview of tax changes over the used periods that affect our data can be found in Federal Tax Administration (1950, 2022).

Additionally, we use historical inflation data from Federal Statistical Office (2023b) to deflate the data to 1947 CHF.

B Additional Empirical Results

B.1 Empirical Strategy across Time

To study the development of municipalities connected to ski areas across time, we use a panel data model:

$$\ln y_{jt} = \alpha_t + \beta_t I_t D_{jt} + \gamma_j + \varepsilon_{jt} \tag{13}$$

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 is equal to 0 for all municipalities in the baseline period, which is always before they gain any access. It equals 1 for all periods after the baseline period for those municipalities that ever gain access to a skiing area. Municipalities that have never access to a ski area indicate $D_{jt} = 0$ at any t. D_{jt} is interacted with a time dummy I_t which equals 1 in period t and 0 otherwise. This allows us to recover time-variant estimates of β_t. α_t is a year fixed effect, γ_j a municipality fixed effect and ε_{jt} is the error term.

We estimate β_t in (1), the association of ski area access to the outcome in period t, by a sequence of these two-by-two DiD estimations where t is the second period and t_0 is always the first period. In particular, we estimate:

$$\Delta_0 \ln y_{jt} = \Delta_0 \alpha_t + \beta_t I_t D_j + \epsilon_{jt}, \tag{14}$$

where $\Delta_0 \ln y_{jt} = \ln y_{jt} - \ln y_{j,t_0}$ is the difference of the outcome at each t to the baseline period, $\Delta_0 \alpha_t = \alpha_t - \alpha_{t_0}$ is a year fixed effect, $D_j = \Delta_0 D_{jt} = D_{jt} - D_{jt_0}$ 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 Figure 2) and 0 otherwise.[41] Note that it is not time-variant for $t > t_0$. The municipality fixed effect γ_j cancels and ϵ_{jt} is the error term.

B.2 Spatial Dispersion

We adapt (2) by changing the treatment to road distance rings in order to tackle the question of how far in space ski area investments affect outcomes. We follow Butts (2023) and estimate

$$\Delta \ln y_{jt} = \alpha_t + \sum_{r=1}^{R} \beta_r D_{jr} + \varepsilon_j, \tag{15}$$

where $\Delta \ln y_{jt} = \ln y_{j,t_1} - \ln y_{j,t_0}$ and β_r are the coefficients of interest that recover the association of each 1km road distance ring r between 1 and 10km. The treatment indicator $D_{jr} = \mathbb{1}\left[\Delta capc_{j,t\in\{t_0,t_1\}} \in (\underline{r}, \overline{r}]\right]$ is a binary treatment indicator that is equal to one if a municipality has access to a capacity increase in at least one ski area in road distance between $\underline{r}$ and $\overline{r}$ (=1km) within the period $t_0 = 1940$ and $t_1 = 1980$ ($t_0 = 1947$ and $t_1 = 1980$ using tax data), or $t_0 = 1980$ and $t_1 = 2020$ ($t_0 = 1980$ and $t_1 = 2015$ using tax data) and zero otherwise. We use capacity increases instead of ski area access as treatment because all areas were built until 1982 and our interest lies in the period after 1980.

The road distance between ski area access points and municipality centers is computed using the Here API. Municipalities always get the closest ski area access point allocated (i.e., each municipality is only accessed once per time period even if a second ski area is located in less than 10km road distance).

This specification allows for testing the spatial dispersion of capacity changes during the ski area access period and the expansion plus concentration phase. Before we get to the results, we first check how far municipality centers lie from the access points differentiated by the treatment indicator from (2) and (3) used in our main specifications.

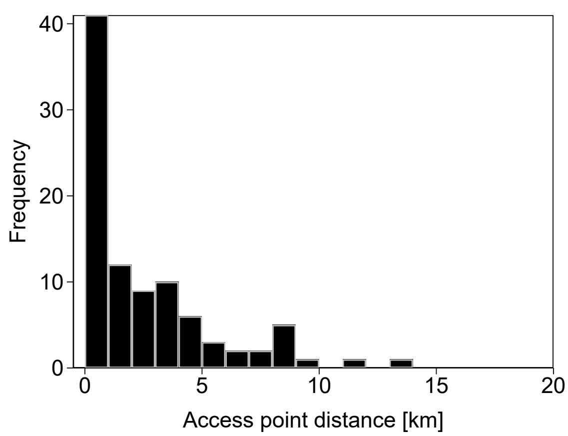
Considering Figure 4, we show that variation in capacity changes of below 2km road distance originates almost exclusively from access municipalities in the main specifications. The two first bins at the very left are large in panel (a) (most capacity changes happen within 2km in municipalities with access points in their jurisdiction), whereas almost negligible in

[41] We estimate β_t in differences because of the simplicity in implementation and interpretation, especially in regressions with only one additional time period to the baseline period (which is simply a cross-sectional regression).

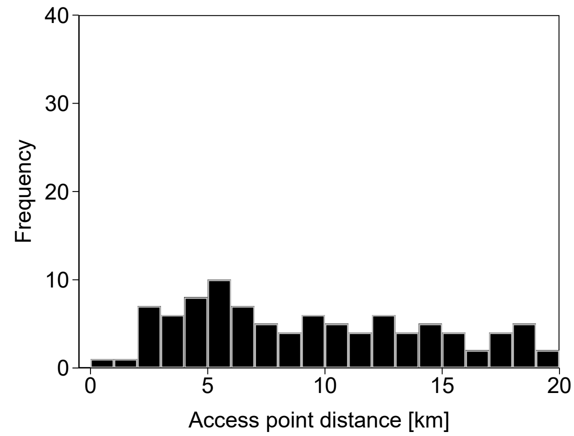
panel (b) (almost no capacity changes happen within 2km in municipalities without access). At the bins between 3 and 5 km, capacity changes disperse roughly in equal measure to municipalities with and without access points and the bins above 5km show that most capacity changes are captured by municipalities without access points. The same pattern can be observed in panels (c) and (d) for the period between 1980 and 2020.

Figure 4: Distribution of municipalities' road distance to ski area access points with capacity changes

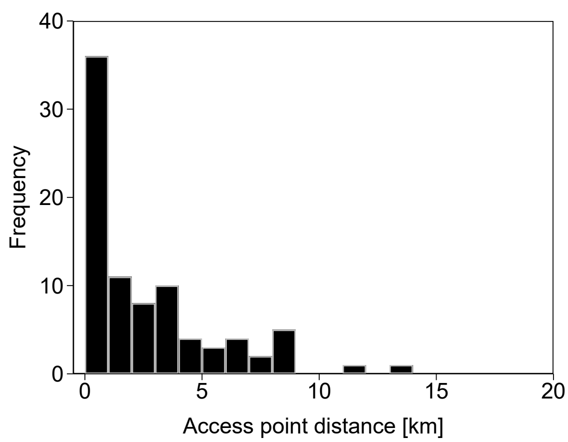
(a) Capacity changes 1940-1980, with access



(b) Capacity changes 1940-1980, w/o access



(c) Capacity changes 1980-2020, with access



(d) Capacity changes 1980-2020, w/o access

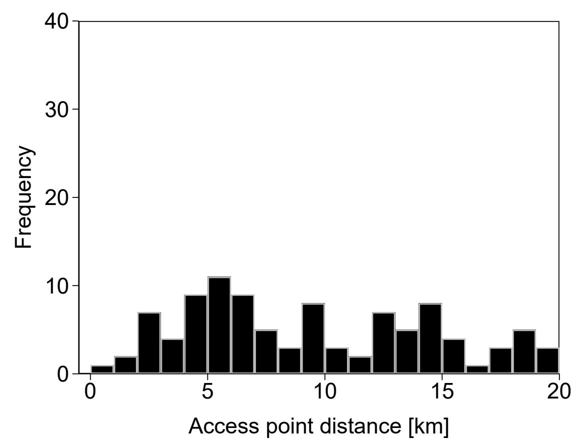


Figure Notes: The bars indicate the distribution of municipalities that are exposed to capacity changes at access points within certain road distances for four groups. Panel (a) shows the distance bins for capacity changes from 1940 to 1980 of municipalities with ski area access in the main specification (2) and (3). Panel (b) shows the same distribution for municipalities without ski area access in the main specification and panels (c) and (d) show the same distribution for capacity changes between 1980 and 2020. Municipalities without access points within 20km are not depicted.

Table 7 shows OLS estimates of (15) for different numbers of rings and two periods using population as the outcome. It is striking how capacity investments until 1980 correlate strongly with population changes at the inner two rings within 2km. Therefore, between 1940 and 1980, municipalities within a 2km road distance of ski area access points grew substantially more than municipalities farther away. This relationship changes completely when we look at changes between 1980 and 2020. The closest municipalities within 2km grow no longer when exposed to capacity changes. Only municipalities further from the access points than 2km are positively related to capacity changes. As Figure 4 indicated, capacity changes above 2km might be driven by municipalities with and without access points in their jurisdiction. Consequently, the SUTVA assumption in the main specification (2) using population data holds before 1980 but is clearly violated thereafter.

Table 7: Association of ski area capacity with population using road distance rings

Dependent variable	Log permanent residents (1980-1940)					Log permanent residents (2020-1980)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capacity change at distance $(0,1]$	0.202^{***}	0.202^{***}	0.214^{***}	0.233^{***}	0.238^{***}	0.044	0.066	0.065	0.073	0.068
	(0.061)	(0.062)	(0.063)	(0.064)	(0.065)	(0.053)	(0.054)	(0.055)	(0.054)	(0.055)
Capacity change at distance $(1,2]$	0.344^{***}	0.344^{***}	0.356^{***}	0.375^{***}	0.380^{***}	0.010	0.031	0.031	0.038	0.033
	(0.087)	(0.088)	(0.089)	(0.089)	(0.090)	(0.084)	(0.084)	(0.085)	(0.085)	(0.085)
Capacity change at distance $(2,3]$	0.161	0.161	0.173	0.192	0.197	0.271^{***}	0.292^{***}	0.292^{***}	0.300^{***}	0.295^{***}
	(0.118)	(0.119)	(0.119)	(0.120)	(0.121)	(0.083)	(0.084)	(0.084)	(0.084)	(0.085)
Capacity change at distance $(3,4]$	0.011	0.011	0.023	0.042	0.047	$0.208^{\dagger}$	$0.229^{\dagger}$	$0.229^{\dagger}$	$0.237^{\dagger}$	$0.232^{\dagger}$
	(0.077)	(0.078)	(0.078)	(0.079)	(0.080)	(0.117)	(0.117)	(0.118)	(0.118)	(0.119)
Capacity change at distance $(4,5]$	0.023	0.023	0.035	0.054	0.060	$0.138^{\dagger}$	$0.159^{\dagger}$	$0.159^{\dagger}$	0.166^{*}	$0.162^{\dagger}$
	(0.096)	(0.096)	(0.097)	(0.097)	(0.098)	(0.081)	(0.081)	(0.082)	(0.082)	(0.083)
Capacity change at distance $(5,6]$	−0.003	−0.003	0.009	0.028	0.033	0.100	0.122	0.121	0.129	0.124
	(0.104)	(0.104)	(0.105)	(0.105)	(0.106)	(0.102)	(0.103)	(0.103)	(0.103)	(0.104)
Capacity change at distance $(6,7]$		−0.001	0.012	0.031	0.036		$0.198^{\dagger}$	$0.197^{\dagger}$	$0.205^{\dagger}$	$0.200^{\dagger}$
		(0.063)	(0.064)	(0.065)	(0.066)		(0.114)	(0.115)	(0.115)	(0.115)
Capacity change at distance $(7,8]$			$0.177^{\dagger}$	$0.196^{\dagger}$	$0.202^{\dagger}$			−0.007	0.000	−0.004
			(0.099)	(0.100)	(0.101)			(0.108)	(0.108)	(0.108)
Capacity change at distance $(8,9]$				$0.200^{\dagger}$	$0.205^{\dagger}$				0.096	0.091
				(0.112)	(0.113)				(0.189)	(0.190)
Capacity change at distance $(9,10]$					0.067					−0.056
					(0.075)					(0.130)
Intercept	-0.128^{***}	-0.128^{***}	-0.140^{***}	-0.159^{***}	-0.164^{***}	0.119^{***}	0.098^{***}	0.098^{***}	0.090^{*}	0.095^{*}
	(0.028)	(0.030)	(0.032)	(0.033)	(0.035)	(0.031)	(0.032)	(0.034)	(0.033)	(0.034)
N units with access	114	123	130	139	146	106	119	126	134	142
N units w/o access	111	102	95	86	79	119	106	99	91	83
N overall	225	225	225	225	225	225	225	225	225	225
R^2	0.098	0.098	0.106	0.118	0.119	0.061	0.080	0.080	0.082	0.083

Table Notes: The table depicts OLS estimates of specification (15). In particular, the average association of capacity investments within a certain road distance to a municipality with population differences between 1940 and 1980 (columns 1-5) and between 1980 and 2020 (columns 6-10). Standard errors are in parentheses and clustered at the municipality level to account for intra-cluster correlations across time.

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

Tables 8 and 9 show OLS estimates of (15) for different numbers of rings and two periods using aggregate taxable income and tax revenues as outcomes. In line with the population results, capacity investments up to 1980 correlate more strongly with outcome changes at the inner rings. Also here the changes disperse more to municipalities further away in the second period between 1980 and 2015. The difference is that there seems to be a relationship of up to 3km before 1980, indicating that SUTVA is somewhat violated. Consequently, the SUTVA assumption in the main specification (2) using income and tax revenue data seems partially violated before 1980 but clearly thereafter.

Table 8: Association of ski area capacity with aggregate incomes using road distance rings

Dependent variable	Log taxable income (1980-1947)					Log taxable income (1980-2015)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capacity change at distance $(0, 1]$	0.264^{*}	0.289^{*}	0.296^{*}	0.335^{*}	0.352^{*}	0.030	0.054	0.048	0.061	0.058
	(0.124)	(0.124)	(0.126)	(0.126)	(0.127)	(0.065)	(0.066)	(0.067)	(0.068)	(0.069)
Capacity change at distance $(1, 2]$	0.422^{*}	0.448^{*}	0.454^{*}	0.493^{*}	0.510^{*}	−0.047	−0.022	−0.029	−0.015	−0.019
	(0.187)	(0.187)	(0.188)	(0.189)	(0.190)	(0.094)	(0.095)	(0.096)	(0.096)	(0.097)
Capacity change at distance $(2, 3]$	0.422^{*}	0.447^{*}	0.454^{*}	0.493^{*}	0.510^{*}	0.214^{*}	0.238^{*}	0.232^{*}	0.245^{*}	0.242^{*}
	(0.189)	(0.190)	(0.191)	(0.191)	(0.192)	(0.104)	(0.104)	(0.105)	(0.106)	(0.107)
Capacity change at distance $(3, 4]$	0.189	0.215	0.221	0.260	0.277	$0.247^{\dagger}$	0.271^{*}	0.265^{*}	0.278^{*}	0.275^{*}
	(0.181)	(0.181)	(0.182)	(0.183)	(0.184)	(0.130)	(0.130)	(0.131)	(0.132)	(0.132)
Capacity change at distance $(4, 5]$	0.149	0.175	0.182	$0.220^{\dagger}$	$0.237^{\dagger}$	0.077	0.102	0.095	0.109	0.105
	(0.123)	(0.124)	(0.125)	(0.126)	(0.127)	(0.106)	(0.107)	(0.108)	(0.108)	(0.109)
Capacity change at distance $(5, 6]$	0.116	0.142	0.149	0.187	0.204	0.069	0.093	0.087	0.100	0.097
	(0.234)	(0.235)	(0.236)	(0.237)	(0.238)	(0.120)	(0.120)	(0.121)	(0.122)	(0.123)
Capacity change at distance $(6, 7]$		0.394	0.400	$0.439^{\dagger}$	$0.456^{\dagger}$		$0.245^{\dagger}$	$0.238^{\dagger}$	$0.252^{\dagger}$	$0.248^{\dagger}$
		(0.258)	(0.259)	(0.260)	(0.261)		(0.124)	(0.125)	(0.125)	(0.126)
Capacity change at distance $(7, 8]$			0.130	0.168	0.185			−0.088	−0.074	−0.078
			(0.147)	(0.148)	(0.149)			(0.071)	(0.072)	(0.073)
Capacity change at distance $(8, 9]$				0.463^{*}	0.480^{*}				0.169	0.165
				(0.187)	(0.188)				(0.151)	(0.152)
Capacity change at distance $(9, 10]$					0.281					−0.048
					(0.204)					(0.158)
Intercept	1.557^{***}	1.531^{***}	1.524^{***}	1.486^{***}	1.469^{***}	0.598^{***}	0.574^{***}	0.580^{***}	0.567^{***}	0.570^{***}
	(0.052)	(0.052)	(0.054)	(0.055)	(0.057)	(0.034)	(0.035)	(0.038)	(0.039)	(0.040)
N units with access	105	113	119	128	134	107	119	127	135	142
N units w/o access	122	114	108	99	93	120	108	100	92	85
N overall	227	227	227	227	227	227	227	227	227	227
R^2	0.059	0.072	0.073	0.093	0.098	0.042	0.062	0.064	0.070	0.071

Table Notes: The table depicts OLS estimates of (15). In particular, the average association of capacity investments within a certain road distance to a municipality with taxable income differences between 1947 and 1980 (columns 1-5) and between 1980 and 2015 (columns 6-10). Standard errors are in parentheses and clustered at the municipality level to account for intra-cluster correlations across time.

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

Table 9: Association of ski area capacity with tax revenue using road distance rings

Dependent variable	Log federal tax revenue (1980-1947)					Log federal tax revenue (2015-1980)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Capacity change at distance $(0, 1]$	0.430^{*}	0.466^{***}	0.468^{***}	0.518^{***}	0.539^{***}	-0.005	0.031	0.026	0.046	0.039
	(0.160)	(0.159)	(0.161)	(0.162)	(0.163)	(0.126)	(0.127)	(0.129)	(0.129)	(0.130)
Capacity change at distance $(1, 2]$	$0.475^{\dagger}$	$0.510^{\dagger}$	$0.512^{\dagger}$	0.562^{*}	0.584^{*}	-0.140	-0.105	-0.109	-0.089	-0.096
	(0.272)	(0.272)	(0.273)	(0.274)	(0.275)	(0.155)	(0.156)	(0.157)	(0.158)	(0.159)
Capacity change at distance $(2, 3]$	0.736^{*}	0.772^{***}	0.774^{***}	0.824^{***}	0.845^{***}	0.151	0.187	0.182	0.202	0.195
	(0.264)	(0.264)	(0.265)	(0.266)	(0.268)	(0.162)	(0.163)	(0.165)	(0.165)	(0.166)
Capacity change at distance $(3, 4]$	0.187	0.223	0.225	0.275	0.297	0.539^{***}	0.574^{***}	0.570^{***}	0.590^{***}	0.583^{***}
	(0.245)	(0.246)	(0.247)	(0.248)	(0.249)	(0.188)	(0.189)	(0.190)	(0.191)	(0.192)
Capacity change at distance $(4, 5]$	0.150	0.186	0.188	0.238	0.260	0.004	0.039	0.035	0.055	0.048
	(0.220)	(0.220)	(0.221)	(0.222)	(0.223)	(0.196)	(0.197)	(0.199)	(0.199)	(0.200)
Capacity change at distance $(5, 6]$	0.287	0.323	0.325	0.375	0.396	0.013	0.048	0.044	0.064	0.057
	(0.314)	(0.314)	(0.316)	(0.317)	(0.318)	(0.181)	(0.182)	(0.184)	(0.184)	(0.185)
Capacity change at distance $(6, 7]$		0.548	0.550	0.600	0.621		$0.357^{\dagger}$	$0.353^{\dagger}$	$0.373^{\dagger}$	$0.365^{\dagger}$
		(0.395)	(0.397)	(0.398)	(0.399)		(0.187)	(0.188)	(0.189)	(0.190)
Capacity change at distance $(7, 8]$			0.038	0.088	0.110			-0.056	-0.036	-0.043
			(0.216)	(0.216)	(0.218)			(0.162)	(0.163)	(0.164)
Capacity change at distance $(8, 9]$				0.600^{*}	0.621^{*}				0.249	0.241
				(0.284)	(0.285)				(0.243)	(0.244)
Capacity change at distance $(9, 10]$					0.352					-0.094
					(0.239)					(0.240)
Intercept	2.204^{***}	2.168^{***}	2.166^{***}	2.116^{***}	2.095^{***}	0.692^{***}	0.657^{***}	0.661^{***}	0.641^{***}	0.648^{***}
	(0.070)	(0.069)	(0.072)	(0.072)	(0.075)	(0.052)	(0.054)	(0.057)	(0.058)	(0.060)
N units with access	105	113	119	128	134	107	119	127	135	142
N units w/o access	122	114	108	99	93	120	108	100	92	85
N overall	227	227	227	227	227	227	227	227	227	227
R^2	0.075	0.088	0.088	0.106	0.110	0.050	0.066	0.066	0.071	0.072

Table Notes: The table depicts OLS estimates of specification (15). In particular, the average association of capacity investments within a certain road distance to a municipality with tax revenue differences between 1947 and 1980 (columns 1-5) and between 1980 and 2015 (columns 6-10). Standard errors are in parentheses and clustered at the municipality level to account for intra-cluster correlations across time.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.3 Productivity Differences due to the Labor Composition

In this section, we provide a back-of-the-envelope estimate of how much the sectoral employment composition of an access municipality affects the local GDP. We complement employment estimates with GDP and productivity estimates from Rütter and Rütter-Fischbacher (2016). Their estimates are available for three municipality types: Cities, Alpine area and rest. The Alpine area does not perfectly coincide with our study area. It also includes early accessed municipalities and some municipalities with peaks below 750 m.a.s.l. (compare Figure 3 to "Abbildung 3" in Rütter and Rütter-Fischbacher (2016)).[42] Nonetheless, these numbers provide estimates of the average sectoral productivity that we combine with our employment associations to give a rough idea of how much access municipalities are affected in terms of local GDP when labor productivity changes across sectors are considered.

Table 10 shows how the labor composition affects the local GDP. We use an average-sized access municipality wherein 492.3 FTE are employed. Then, we take the difference in worker compositions across sectors of municipalities without (NAC) versus those with access (AC). For this, we calculate the average employment share per sector of municipalities without access and add OLS estimates of specification (3) for each sector to get the employment share of access municipalities. The sectoral employment compositions of those municipalities are depicted in columns (a) and (b) in Table 10.

Furthermore, we take GDP and employment estimates by Rütter and Rütter-Fischbacher (2016) (columns under (c)), calculate the labor productivity as GDP/FTE ratio (column (d)) and multiply it with the FTE from the employment composition to get a GDP estimate for municipalities with and without access (columns under (e)). The difference between the two yields our effect estimates depicted in the columns under (f) regarding FTE and local GDP.

Table 10 shows that municipality employment shifted from agriculture to tourism-related and other services, mainly driven by employment opportunities in the accommodation sector and, to a smaller extent, in the gastronomy and retail sector. As labor productivity is higher in services than in agriculture, we estimate that a municipality with access to at least one ski area gains, on average, 1.4 Million 2015 CHF in terms of gross value added compared to a municipality without such access. We estimate accordingly an average compositional effect of 2.9% on local GDP.

[42] As the main purpose of their paper is to evaluate the GDP and employment effects that can be attributed to tourism, their municipality definition is based on Swiss Tourism, the national tourism marketing organization.

Table 10: Association of ski area access with the local GDP in 2015 of an average-sized access municipality

Sectors		(a) Composition NAC		(b) Composition AC		(c) Alpine area GDP & FTE		(d) GDP/FTE	(e) GDP estimate		(f) Effect estimate		
[name]	[ISIC]	[share]	[FTE]	[share]	[FTE]	[Mio. CHF]	[FTE]	[CHF]	NAC [CHF]	AC [CHF]	[FTE]	[CHF]	[%]
Tourism-related services	*	0.18	90.5	0.32	155.5	4,800	72,260	66,427	6,010,402	10,327,463	65.0	4,317,061	71.8
Agriculture and forestry	01-03	0.30	148.3	0.17	85.3	900	26,120	34,456	5,110,929	2,939,477	-63.0	-2,171,452	-42.5
Industry and commerce	10-33	0.10	49.2	0.09	44.8	9,600	62,170	154,415	7,596,725	6,912,492	-4.4	-684,233	-9.0
Energy, water, mining	05-09,35-39	0.02	10.1	0.01	5.1	2,100	7,670	273,794	2,757,125	1,409,110	-4.9	-1,348,015	-48.9
Construction	41-43	0.16	77.7	0.15	75.7	5,400	51,410	105,038	8,158,020	7,951,160	-2.0	-206,860	-2.5
Other services	45-98**	0.24	116.6	0.26	126.0	32,600	201,480	161,803	18,866,238	20,379,836	9.4	1,513,598	8.0
Total		1	492.3	1	492.3	55,400	421,110	131,557	48,499,436	49,919,536	0	1,420,098	2.9

Table Notes: The table depicts an average-sized access municipality in the sample ($n = 94$), its employed and worker composition across six sectors in a counterfactual situation with no access (indicated as NAC, columns under (a)) and with access (indicated as AC, columns under (b)), an aggregate GDP and FTE employment estimate of Rütter and Rütter-Fischbacher (2016) (columns under (c)), the resulting GDP per FTE (column (d)), the resulting compositional GDP effects for both municipality types (columns under (e)) and the effect estimates on sectoral employment as well as local GDP (columns under (f)). The effect estimates on employment are OLS estimates of specification (3). In particular, the average effect of getting access to a ski area between 1940 and 1982 on the sectoral employment share of all employed in FTE in 2015.

* Tourism-related services consist of accommodation (55), gastronomy (56), railways (49.1), cableways (49.39), passenger shipping (50.3), passenger road transport (49.3), passenger air transport, travel agencies (79.11), tourism service (79.12), culture, sports and entertainment (90-93), other tourism-related services (94-96).

** Other services include all ISIC codes between 45-98 that are not listed in the tourism-related services.

There are two reasons why this sectoral composition effect might be underestimated. First, differences in sectoral labor productivity growth rates indicate that local GDP effects might have been substantially greater in 1980 than today: The core tourism-related services such as accommodation and gastronomy experienced negative real productivity growth rates while the agricultural sector became more productive between 1997 and 2014 (Federal Statistical Office, 2016). Extrapolating these sectoral trends backward from 2015 (as in Table 10) to 1997 leads to an average compositional GDP effect of 7.7%.[43] Thus, the recent trend of low labor productivity in tourism-related services lessens the positive impact on access municipalities.

If the previous argument were true, why did the differences in sectoral labor productivity rates not lead to a similar convergence in incomes and tax revenues? This can be explained by the spatial spillovers after 1980 and the location at which data is measured. Employment and GDP effects are measured at the firm location, whereas the other outcomes are measured at the residence location of the individuals. After adopting the federal Land Use Planning Act in 1980 (Federal Assembly of Switzerland, 1979), commuting to the workplace became more attractive and, thus, spillover effects to neighboring municipalities more likely (consider Appendix B.2). Therefore, from 1980 onwards, the converging GDP effects at the firm location dispersed (by increases in commuting) in equal size to municipalities with and without access where incomes, population and tax revenues are measured.

Notice that if we consider only statistically significant employment shifts, namely tourism-related services and agriculture, the estimate for the compositional channel increases to 4.4%.

B.4 Federal Tax Base

The results of (14) for the tax base across time are depicted in Figure 5. The changes in aggregate incomes of the access municipalities are represented in panel (a). On average, aggregate taxable incomes are 42% larger in access municipalities as of 1975. The association remains constant after that.

Panel (b) shows that the number of federal taxpayers increased more than the income. Between 1947 and 1985, the number of taxpayers increased by 57% in access municipalities and also remained constant after that.

[43] By assuming the following real annual productivity growth rates in the 18 years between 1997 and 2015: -1% for tourism-related services, 0.8% for other services, 2.3% for agriculture, and 1.2% for the three industry and construction sectors (Federal Statistical Office, 2016).

Figure 5: Association of ski area access with income

(a) Taxable income **(b) Number of federal tax payers**

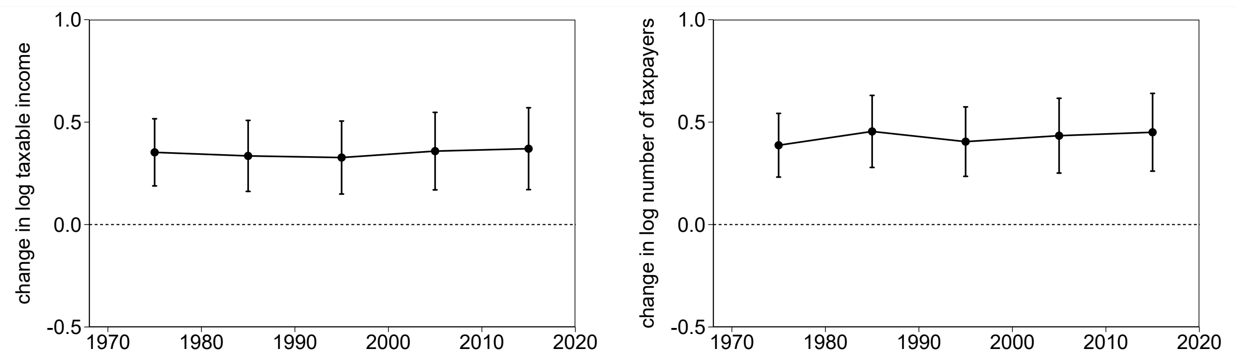


Figure Notes: The points indicate OLS estimates of specification (14). In particular, the association of access to a ski area between 1940 and 1982 with the average municipality taxable income (left panel) and the average tax base population (right panel) across time. The base year $t_0 = 1947$. The access municipalities number to $n = 94$ and the control group municipalities to $n = 133$. Standard errors are clustered on the municipality level to account for intra-cluster correlations across time. The point estimates and standard errors follow in Table 11.

Table 11: The association of ski area access with income across time

Dependent variable:	Log taxable income (a)	Log number of federal tax payers (b)
Ski area access 1975	0.352***	0.387***
	(0.083)	(0.079)
Ski area access 1985	0.335***	0.454***
	(0.088)	(0.089)
Ski area access 1995	0.327***	0.405***
	(0.090)	(0.086)
Ski area access 2005	0.358***	0.434***
	(0.096)	(0.093)
Ski area access 2015	0.370***	0.450***
	(0.101)	(0.096)
Year fixed effect 1975	1.356***	0.546***
	(0.048)	(0.043)
Year fixed effect 1985	1.680***	0.932***
	(0.050)	(0.047)
Year fixed effect 1995	2.081***	1.198***
	(0.050)	(0.046)
Year fixed effect 2005	2.112***	1.172***
	(0.056)	(0.052)
Year fixed effect 2015	2.165***	1.094***
	(0.062)	(0.056)
N overall	1,135	1,135
R^2	0.906	0.787

Table Notes: The coefficient table corresponds to Figure 5.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.5 Federal Tax Revenue

The results of (14) for tax revenues across time are depicted in Figure 6. The changes in tax revenues of the access municipalities are represented in panel (a). On average, tax revenues are 72% larger in access municipalities in 1975 and remained constant thereafter.

Panel (b) depicts a 53% higher tax revenue per resident in 1975. Looking at changes between 1947 and 2015, the association settles at 40%.

Figure 6: Association of ski area access with federal tax revenue

(a) Tax revenue **(b) Tax revenue per resident**

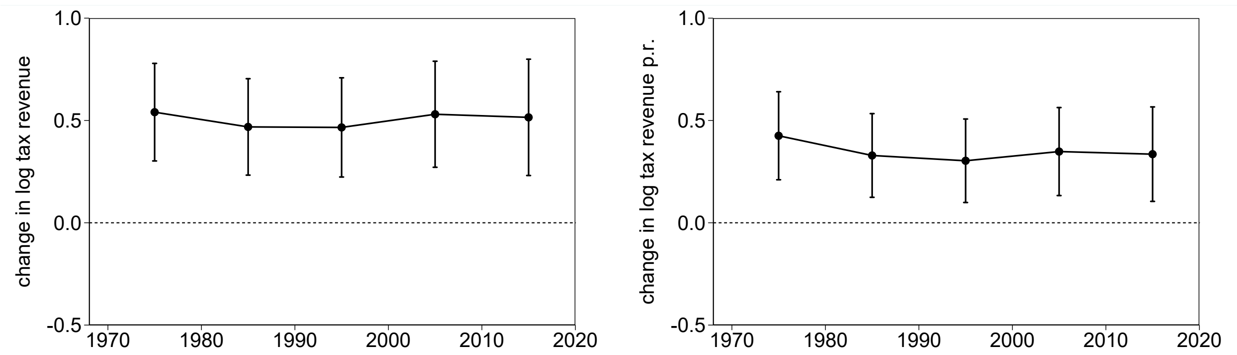


Figure Notes: The points indicate OLS estimates of specification (14). In particular, the association of access to a ski area between 1940 and 1982 with the average federal tax revenue (left panel) and the average federal tax revenue per resident (right panel) across time. The baseline period is $t_0 = 1947$. The access municipalities number to $n = 94$ and the control group municipalities to $n = 133$. Standard errors are clustered on the municipality level to account for intra-cluster correlations across time. The point estimates and standard errors follow in Table 12.

Table 12: The association of ski area access with federal tax revenues across time

Dependent variable:	Log federal tax revenue (a)	Log federal tax revenue per resident (b)
Ski area access 1975	0.541^{***}	0.425^{***}
	(0.121)	(0.109)
Ski area access 1985	0.469^{***}	0.329^{**}
	(0.120)	(0.104)
Ski area access 1995	0.466^{***}	0.303^{**}
	(0.123)	(0.104)
Ski area access 2005	0.530^{***}	0.348^{**}
	(0.132)	(0.109)
Ski area access 2015	0.515^{***}	0.335^{**}
	(0.144)	(0.117)
Year fixed effect 1975	1.815^{***}	1.909^{***}
	(0.072)	(0.066)
Year fixed effect 1985	2.428^{***}	2.524^{***}
	(0.069)	(0.058)
Year fixed effect 1995	2.852^{***}	2.816^{***}
	(0.070)	(0.057)
Year fixed effect 2005	2.777^{***}	2.756^{***}
	(0.078)	(0.058)
Year fixed effect 2015	2.901^{***}	2.857^{***}
	(0.089)	(0.066)
N overall	1,135	1,135
R^2	0.902	0.926

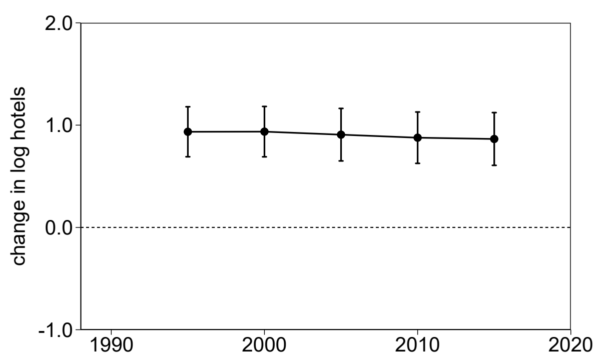
Table Notes: The coefficient table corresponds to Figure 6.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.6 Hotels

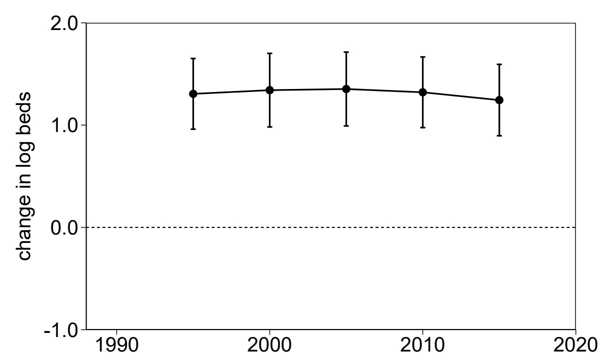
To check whether the association with the accommodation employment share in 2015 is not driven by structural changes after 1995, we use HESTA data on the number of hotels, hotel beds and hotel rooms. The assumption is that a constant supply of hotels of approximately the same size would not induce any strong variation in accommodation employment over time. This is exactly what Figure 7 confirms. It depicts OLS estimates of specification (3). In 1995, access municipalities had on average 155% more hotels, with 269% more hotel beds and 252% more hotel rooms than municipalities without access. These numbers decrease to 137% more hotels, 247% more hotel beds and 224% more hotel rooms in 2015.

Figure 7: Association of ski area access with hotels

(a) Hotels



(b) Hotel beds



(c) Hotel rooms

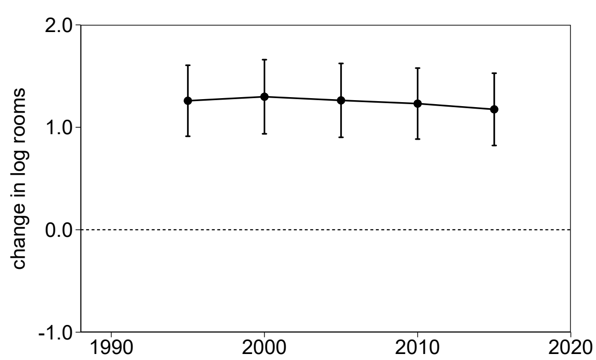


Figure Notes: The points indicate OLS estimates of specification (3). In particular, the association of getting access to a ski area between 1940 and 1982 with the average number of hotels (top left panel), the average number of hotel beds (top right panel) and the average number of hotel rooms (bottom left panel) across time (5 years interval). The access municipalities number to $n = 94$ and the units without access to $n = 133$. Standard errors are clustered on the municipality level. The point estimates and standard errors follow in Table 13.

Table 13: The association of ski area access with hotels across time

Dependent variable:	Log hotels (a)	Log beds (b)	Log rooms (c)
Ski area access 1995	0.935***	1.306***	1.259***
	(0.124)	(0.175)	(0.176)
Ski area access 2000	0.936***	1.342***	1.298***
	(0.125)	(0.182)	(0.183)
Ski area access 2005	0.907***	1.353***	1.263***
	(0.130)	(0.183)	(0.183)
Ski area access 2010	0.877***	1.321***	1.231***
	(0.127)	(0.175)	(0.176)
Ski area access 2015	0.865***	1.245***	1.175***
	(0.131)	(0.177)	(0.179)
Year fixed effect 1995	1.012***	4.100***	3.448***
	(0.078)	(0.113)	(0.113)
Year fixed effect 2000	0.972***	4.060***	3.398***
	(0.080)	(0.125)	(0.126)
Year fixed effect 2005	0.942***	4.050***	3.351***
	(0.083)	(0.123)	(0.123)
Year fixed effect 2010	0.974***	4.176***	3.435***
	(0.080)	(0.118)	(0.119)
Year fixed effect 2015	0.916***	4.178***	3.411***
	(0.086)	(0.121)	(0.122)
N overall	1,148	1,148	1,148
R^2	0.635	0.790	0.774

Table Notes: The coefficient table corresponds to Figure 7.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

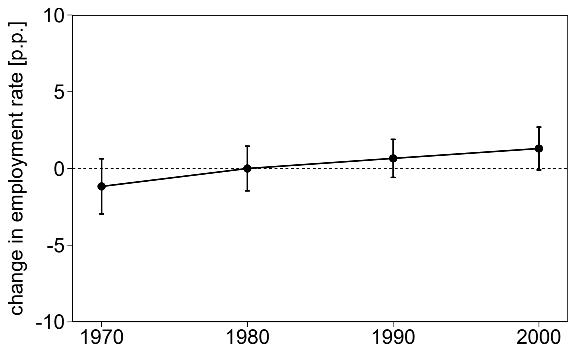
B.7 Employment Rate

The points in Figure 8 depict estimates of (3) at decades between 1970 and 2000. Panel (a) depicts the association of ski area access and the employment rate (employed population counts divided by the overall population). The difference in employment rates for municipalities with and without access is statistically indistinguishable from zero after 1980 but hints at a slightly positive trend. In 1970 the employment rate is estimated to be 1.17 percentage points lower in access municipalities compared to those without access, whereas, in 2000, the estimates are slightly positive at 1.3 percentage points. This shows that in the aftermath of ski area access, municipalities tend to gain little at the extensive margin in employment, albeit not statistically significant.

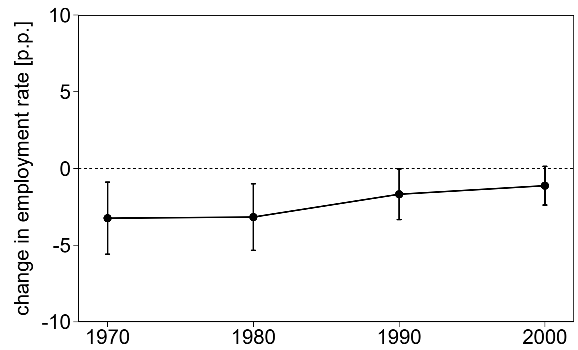
Panels (b) to (d) show the same estimates split by the three economic sectors. The outcomes are defined as counts of employed per sector divided by the overall population. Most notably, access municipalities gained by 1970 3.1 percentage points more employed in the tertiary sector almost exclusively at the expense of the primary sector. Most municipalities had already gained access by that time (86 out of 94) and the association increased slightly to 4.0 percentage points by 1980 and returned approximately to the level of 1970 by 2000. As data is missing before 1970, we do not know whether the employment differences stem from the ski area access period between 1940 and 1982 or were already in place before 1940.

Figure 8: Association of ski area access with employment rate

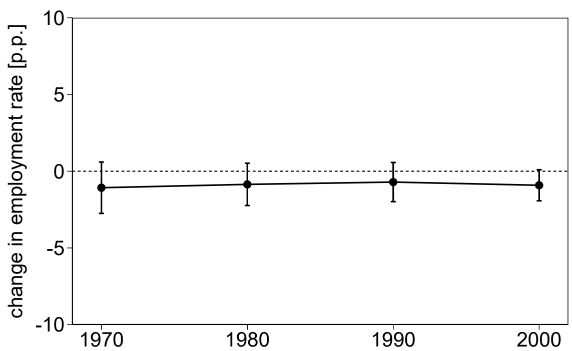
(a) Employment rate



(b) Employment rate primary sector



(c) Employment rate secondary sector



(d) Employment rate tertiary sector

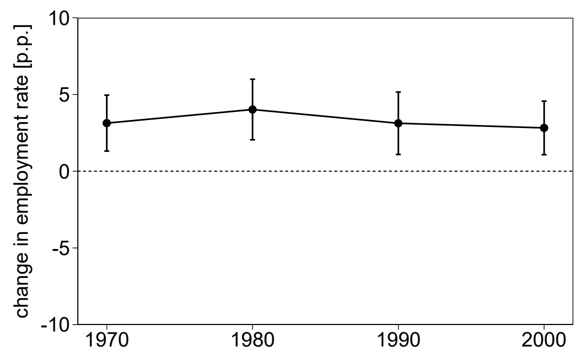


Figure Notes: The points indicate OLS estimates of specification (3). In particular, the association of access to a ski area between 1940 and 1982 with the average employment rate (top left panel), the average employment rate of the primary sector (top right panel), the average employment rate of the secondary sector (bottom left panel) and the average employment rate of the tertiary sector (bottom right panel) across time (10 years interval). The employment rate is defined as counts of the employed (by sector) divided by population counts. The access municipalities number to $n = 94$ and the units without access to $n = 133$. Standard errors are clustered at the municipality level. The point estimates and standard errors follow in Table 14.

Table 14: The association of ski area access with the employment rate across time

Dependent variable:	Employment rate			
	Overall (a)	Primary sector (b)	Secondary sector (c)	Tertiary sector (d)
Ski area access 1970	-1.170	-3.240^{**}	-1.075	3.136^{***}
	(0.912)	(1.192)	(0.849)	(0.926)
Ski area access 1980	-0.002	-3.167^{**}	-0.857	4.020^{***}
	(0.740)	(1.101)	(0.699)	(1.001)
Ski area access 1990	0.658	-1.679^{*}	-0.708	3.125^{**}
	(0.630)	(0.838)	(0.648)	(1.032)
Ski area access 2000	$1.299^{\dagger}$	$-1.123^{\dagger}$	$-0.915^{\dagger}$	2.822^{**}
	(0.709)	(0.641)	(0.514)	(0.887)
Year fixed effect 1970	44.777^{***}	15.718^{***}	16.097^{***}	12.954^{***}
	(0.619)	(0.818)	(0.684)	(0.533)
Year fixed effect 1980	45.586^{***}	12.880^{***}	15.360^{***}	16.997^{***}
	(0.487)	(0.756)	(0.513)	(0.530)
Year fixed effect 1990	46.191^{***}	7.547^{***}	13.437^{***}	23.303^{***}
	(0.415)	(0.570)	(0.424)	(0.631)
Year fixed effect 2000	48.226^{***}	5.916^{***}	11.143^{***}	23.494^{***}
	(0.409)	(0.414)	(0.356)	(0.514)
N overall	908	908	908	908
R^2	0.986	0.667	0.871	0.903

Table Notes: The coefficient table corresponds to Figure 8.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.8 Employment: IPW

Table 15 shows estimates of specification (3) using inverse propensity score weighting. The outcomes are computed using STATENT data across 2-digit ISIC industries in 2015. The treatment is defined in the usual way. Propensity scores are estimated using a binary logit model and the standard errors are computed using the bootstrap with 200 repetitions. Columns (1) to (4) show the resulting estimates of the employment share in accommodation, gastronomy, retail and agriculture, respectively. All estimates are around the same size as in the main specification in Table 3.

Table 15: Association of ski area access with employment shares in 2015 using inverse propensity score weighting

Dependent variable:	Accommodation [%]	Gastronomy [%]	Retail [%]	Agriculture [%]
	(1)	(2)	(3)	(4)
Ski area access	0.048^{**}	0.023^{*}	0.007	-0.093^{***}
	(0.017)	(0.011)	(0.009)	(0.026)
Intercept	0.095^{***}	0.058^{***}	0.046^{***}	0.262^{***}
	(0.013)	(0.008)	(0.008)	(0.022)
N units with access	94	94	94	94
N units w/o access	133	133	133	133
N overall	211	211	211	211

Table Notes: The table depicts estimates of the ATT using inverse propensity score weighting in specification (3). The propensity score is estimated using a logit model with the road distance to the next cantonal center, the Euclidean distance to the next lake, the developable land measure and the sunshine exposure of the developable land as independent variables. The outcomes are 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. Standard errors are in parentheses and are computed using the bootstrap with 200 repetitions.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.9 Employment: Other Sectors

Table 16 depicts OLS estimates of (3) using STATENT data up across 2-digit ISIC industries in 2015. Column (1) shows estimates of employment shares in forestry. Access municipalities have on average the same share of employed full-time equivalents as municipalities without access relative to an employment share of 0.5%. Likewise, columns (2) and (3) show null results for employment shares in manufacturing and in retail. Therefore, increases in tourism-related services do not produce spillovers to unrelated industries within the access municipalities. It is still possible that such effects disperse across municipalities of both treatment statuses.

Table 16: **Association of ski area access with employment shares in 2015**

Dependent variable	Forestry [%] (1)	Manufacturing [%] (2)	Construction [%] (3)
Ski area access	−0.000	−0.009	−0.004
	(0.002)	(0.012)	(0.016)
Intercept	0.005***	0.100***	0.158***
	(0.001)	(0.009)	(0.012)
N units with access	94	94	94
N units w/o access	133	133	133
N overall	227	227	227
R^2	0.000	0.002	0.000

Table Notes: The table depicts OLS estimates of specification (3). In particular, the average association of access to a ski area between 1940 and 1982 with the share of forestry and logging employment (column (1)), the share of manufacturing employment (column (2)) and the share of construction employment (column (3)) of all employed 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 clustered at the municipality level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.10 Agricultural Land Use

In this section, we check in detail how the negative association with the agriculture employment share in 2015 affects land use in access municipalities compared to those without access over time. We use land use data from the area statistics of the FSO. The data allocate each 100-by-100 meter pixel to a certain land use out of 72 categories.

Figure 9 shows OLS estimates of specification (3). It indicates that in access municipalities on average 6.5 p.p. more land is allocated to alpine agriculture relative to a share of 11.7% in municipalities without access. On the contrary, access municipalities allocate 6.4 p.p. less land to valley bottom agriculture relative to a share of 18.0% in municipalities without access. The agricultural land use remains constant over the observed period. Assuming little technological advances in agricultural production would suggest that also the employment effects did not substantially change since 1985.

These results suggest that alpine agriculture complements ski areas on the supply side because the alpine meadows and pastures that are used in summer for agricultural purposes can easily be used for skiing terrain in winter. Moreover, alpine agriculture also complements ski areas in labor demand. Alpine farmers are known to work in ski areas in winter. In a survey, 64% of alpine farmers in Grisons and 51% in the Bernese Highlands state that they earn off-farm income from winter tourism (Behringer et al., 2000).

Figure 9: Association of ski area access with agricultural land use

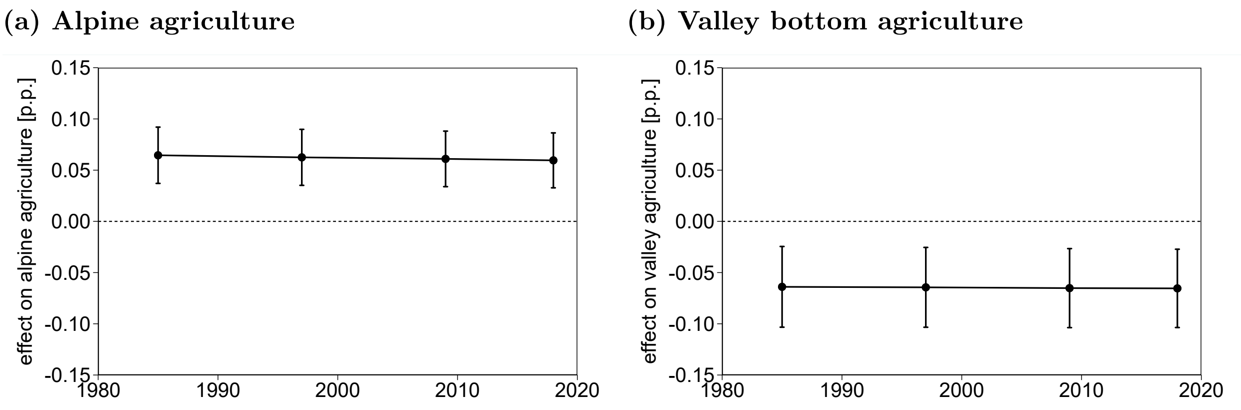


Figure Notes: The points indicate OLS estimates of specification (3). In particular, the average association of access to a ski area between 1940 and 1982 with the average share of alpine agriculture, including alpine meadows and favorable alpine pasture, (left panel) and the average share of valley bottom agriculture (right panel). The access municipalities number to $n = 94$ and the control group municipalities to $n = 133$. Standard errors are clustered on the municipality level. The point estimates and standard errors follow in Table 17.

Table 17: The association of ski area access with federal tax revenues across time

Dependent variable:	Alpine agriculture [%] (a)	Valley bottom agriculture [%] (b)
Ski area access 1985	0.065***	−0.064**
	(0.014)	(0.020)
Ski area access 1997	0.062***	−0.064**
	(0.014)	(0.020)
Ski area access 2009	0.061***	−0.065**
	(0.014)	(0.020)
Ski area access 2018	0.060***	−0.065***
	(0.014)	(0.019)
Year fixed effect 1985	0.117***	0.180***
	(0.009)	(0.018)
Year fixed effect 1997	0.113***	0.176***
	(0.009)	(0.017)
Year fixed effect 2009	0.110***	0.173***
	(0.009)	(0.017)
Year fixed effect 2018	0.107***	0.171***
	(0.009)	(0.017)
N overall	908	908
R^2	0.657	0.463

Table Notes: The coefficient table corresponds to Figure 9.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B.11 Other Land Use

Figure 10 shows OLS estimates of specification (3). It indicates statistically significant associations for service, mixed and unspecified buildings, camping sites, Alpine sport infrastructure and landscape interventions. As expected, all are closely related to tourism-related service industries. More strikingly, the land use estimates show barely any changes during the expansion and concentration phase. Thus, ski area access did not induce any significant land use changes across municipality types after 1985.

Figure 10: Association of ski area access with land use

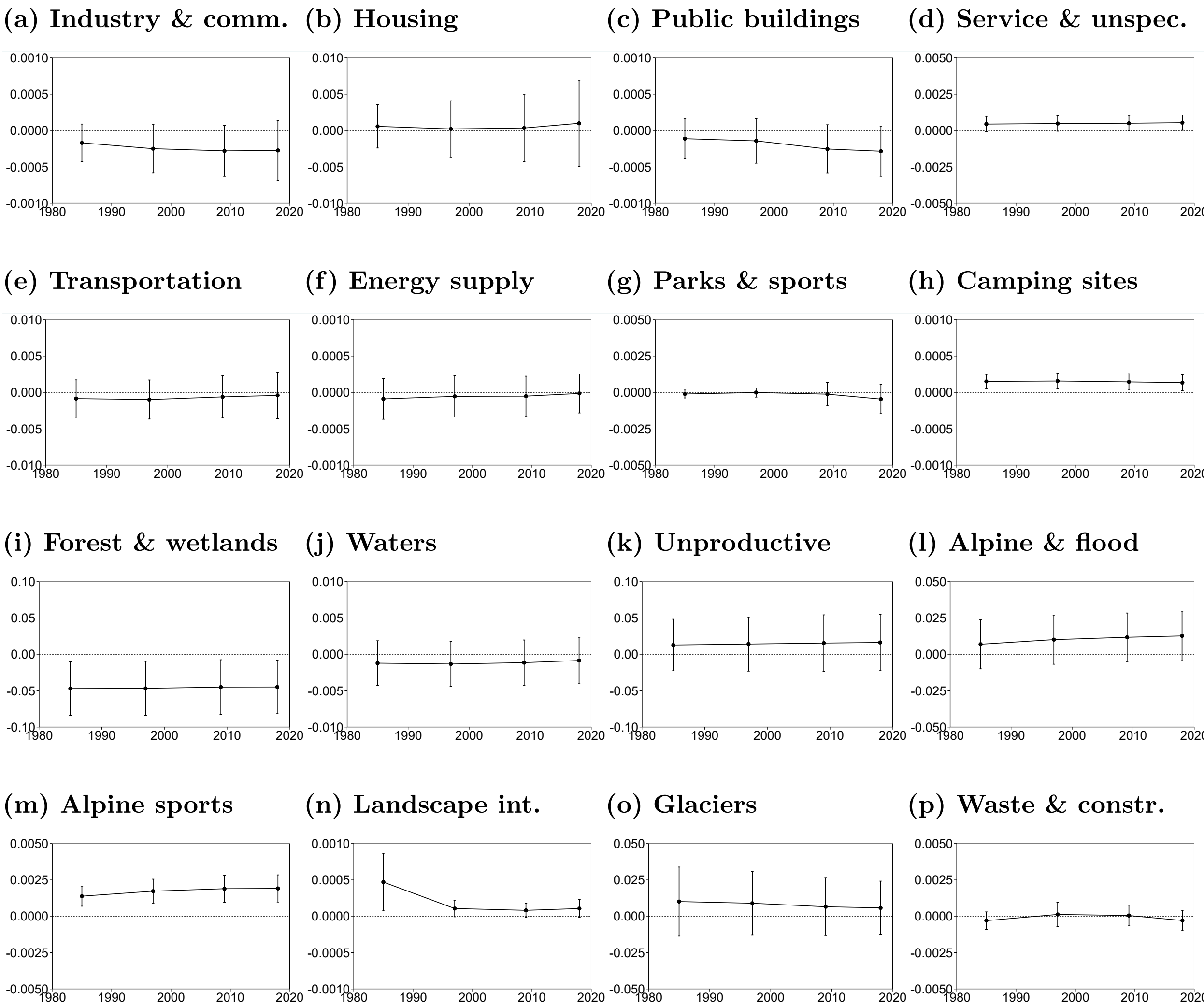


Figure Notes: The points indicate OLS estimates of specification (3). In particular, the average association of access to a ski area between 1940 and 1982 with the average share of the respective land use. The access municipalities number to $n = 94$ and the control group municipalities to $n = 133$. Standard errors are clustered on the municipality level. The point estimates and standard errors follow in Table 18, 19, 20 and 21.

Table 18: The association of ski area access with land use

Dependent variable:	Industry & comm. (a)	Housing (b)	Public buildings (c)	Service & unspec. (d)
Ski area access 1985	−0.00017	0.00058	−0.00011	0.00045†
	(0.00013)	(0.00151)	(0.00014)	(0.00027)
Ski area access 1997	−0.00025	0.00023	−0.00014	0.00049†
	(0.00017)	(0.00196)	(0.00016)	(0.00027)
Ski area access 2009	−0.00028	0.00036	−0.00025	0.00050†
	(0.00018)	(0.00235)	(0.00017)	(0.00027)
Ski area access 2018	−0.00027	0.00100	−0.00028	0.00054*
	(0.00021)	(0.00301)	(0.00017)	(0.00027)
Year fixed effect 1985	0.00063***	0.00662***	0.00060***	0.00098***
	(0.00011)	(0.00113)	(0.00010)	(0.00014)
Year fixed effect 1997	0.00087***	0.00898***	0.00070***	0.00109***
	(0.00015)	(0.00155)	(0.00012)	(0.00013)
Year fixed effect 2009	0.00093***	0.01055***	0.00082***	0.00106***
	(0.00015)	(0.00185)	(0.00013)	(0.00014)
Year fixed effect 2018	0.00102***	0.01195***	0.00087***	0.00104***
	(0.00018)	(0.00212)	(0.00014)	(0.00013)
N overall	908	908	908	908
R^2	0.232	0.242	0.226	0.318

Table Notes: The coefficient table corresponds to panels (a) to (d) in Figure 10.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 19: The association of ski area access with land use

Dependent variable:	Transportation (e)	Energy supply (f)	Parks & sports (g)	Camping sites (h)
Ski area access 1985	-0.00084	-0.00009	-0.00011	0.00015^{**}
	(0.00130)	(0.00014)	(0.00014)	(0.00005)
Ski area access 1997	-0.00097	-0.00005	-0.00000	0.00016^{**}
	(0.00136)	(0.00014)	(0.00016)	(0.00005)
Ski area access 2009	-0.00061	-0.00005	-0.00012	0.00015^{*}
	(0.00147)	(0.00014)	(0.00041)	(0.00006)
Ski area access 2018	-0.00040	-0.00001	-0.00045	0.00013^{*}
	(0.00162)	(0.00014)	(0.00051)	(0.00006)
Year fixed effect 1985	0.01045^{***}	0.00035^{**}	0.00043^{**}	0.00007^{**}
	(0.00076)	(0.00011)	(0.00013)	(0.00002)
Year fixed effect 1997	0.01175^{***}	0.00035^{**}	0.00059^{***}	0.00008^{**}
	(0.00083)	(0.00011)	(0.00014)	(0.00002)
Year fixed effect 2009	0.01218^{***}	0.00034^{**}	0.00114^{**}	0.00012^{***}
	(0.00082)	(0.00011)	(0.00037)	(0.00003)
Year fixed effect 2018	0.01255^{***}	0.00034^{***}	0.00152^{**}	0.00012^{***}
	(0.00084)	(0.00010)	(0.00048)	(0.00003)
N overall	908	908	908	908
R^2	0.554	0.082	0.096	0.176

Table Notes: The coefficient table corresponds to panels (e) to (h) in Figure 10.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 20: The association of ski area access with land use

Dependent variable:	Forest & wetlands (i)	Waters (j)	Unproductive (k)	Alpine & flood (l)
Ski area access 1985	-0.04705^{*}	-0.00121	0.01286	0.00696
	(0.01875)	(0.00156)	(0.01797)	(0.00860)
Ski area access 1997	-0.04673^{*}	-0.00133	0.01415	0.01011
	(0.01888)	(0.00157)	(0.01889)	(0.00857)
Ski area access 2009	-0.04500^{*}	-0.00114	0.01549	0.01174
	(0.01903)	(0.00158)	(0.01970)	(0.00846)
Ski area access 2018	-0.04485^{*}	-0.00085	0.01630	0.01266
	(0.01865)	(0.00158)	(0.01967)	(0.00864)
Year fixed effect 1985	0.30144^{***}	0.01219^{***}	0.18196^{***}	0.09969^{***}
	(0.01361)	(0.00116)	(0.01273)	(0.00639)
Year fixed effect 1997	0.31341^{***}	0.01226^{***}	0.18531^{***}	0.09803^{***}
	(0.01381)	(0.00116)	(0.01331)	(0.00626)
Year fixed effect 2009	0.32162^{***}	0.01250^{***}	0.18724^{***}	0.09575^{***}
	(0.01399)	(0.00118)	(0.01377)	(0.00613)
Year fixed effect 2018	0.32217^{***}	0.01250^{***}	0.19364^{***}	0.09504^{***}
	(0.01377)	(0.00119)	(0.01370)	(0.00621)
N overall	908	908	908	908
R^2	0.808	0.490	0.642	0.704

Table Notes: The coefficient table corresponds to panels (i) to (l) in Figure 10.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 21: The association of ski area access with land use

Dependent variable:	Alpine sports (m)	Landscape int. (n)	Glaciers (o)	Waste & constr. (p)
Ski area access 1985	0.00138***	0.00047*	0.01008	−0.00030
	(0.00035)	(0.00020)	(0.01205)	(0.00030)
Ski area access 1997	0.00172***	0.00011†	0.00892	0.00012
	(0.00042)	(0.00006)	(0.01114)	(0.00042)
Ski area access 2009	0.00189***	0.00008	0.00652	0.00005
	(0.00047)	(0.00005)	(0.01001)	(0.00036)
Ski area access 2018	0.00191***	0.00011†	0.00574	−0.00029
	(0.00047)	(0.00006)	(0.00933)	(0.00035)
Year fixed effect 1985	0.00007*	0.00033***	0.03792***	0.00208***
	(0.00003)	(0.00007)	(0.00818)	(0.00026)
Year fixed effect 1997	0.00010*	0.00019***	0.03211***	0.00178***
	(0.00004)	(0.00004)	(0.00748)	(0.00019)
Year fixed effect 2009	0.00008**	0.00012***	0.02692***	0.00173***
	(0.00003)	(0.00003)	(0.00688)	(0.00021)
Year fixed effect 2018	0.00008**	0.00014***	0.02410***	0.00192***
	(0.00003)	(0.00003)	(0.00646)	(0.00027)
N overall	908	908	908	908
R^2	0.161	0.169	0.154	0.323

Table Notes: The coefficient table corresponds to panels (m) to (p) in Figure 10.
† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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