Climate change and Real Estate Markets

The case of the Swiss Alps

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Why study the Alps?

1. **Climate change occurs faster in Alpine regions**

   → Albedo feedbacks

2. **Economy highly dependent on the right climate**

   → Winter tourism

3. **Limited market size with high variance in climate**

Research Questions

Q1: *What is the relationship between climate (snow cover) and the values of residential real estate in the Swiss Alps?*

Q2: *What is the impact of climate change on the market for residential real estate in Swiss ski resorts?*

Previous attempts

Authors	**Study Region**	**Findings**
Butsic, Hanak, and Valletta (2011)	Rocky Mountains (US)	1% increase in snowfall intensity → 2.16% increase in house prices
Galinato and Tantihkarnchana (2018)	US (multiple regions)	Not snowfall, but temperature is the best predictor of house prices. Relationship non-linear.

- No research for the European Alps so far
- Snow cover duration is the most relevant metric, not snowfall or temperature
- Cross-sectional studies only → not climate change!

Approach

1. Is proximity to a ski resort a valuable amenity?
    - Does the value of this amenity differ by use?
2. Are agents willing to pay a premium for increased snow cover?
3. Does it matter whether snow is real or artificial?
    - Snowmaking will be possible for a very long time
4. Changes in Snow Cover Duration over time
    - Still in progress

Data

14,128 Transactions (Source: SRED)

- 99 Municipalities
- 2000-2020 (T=21)

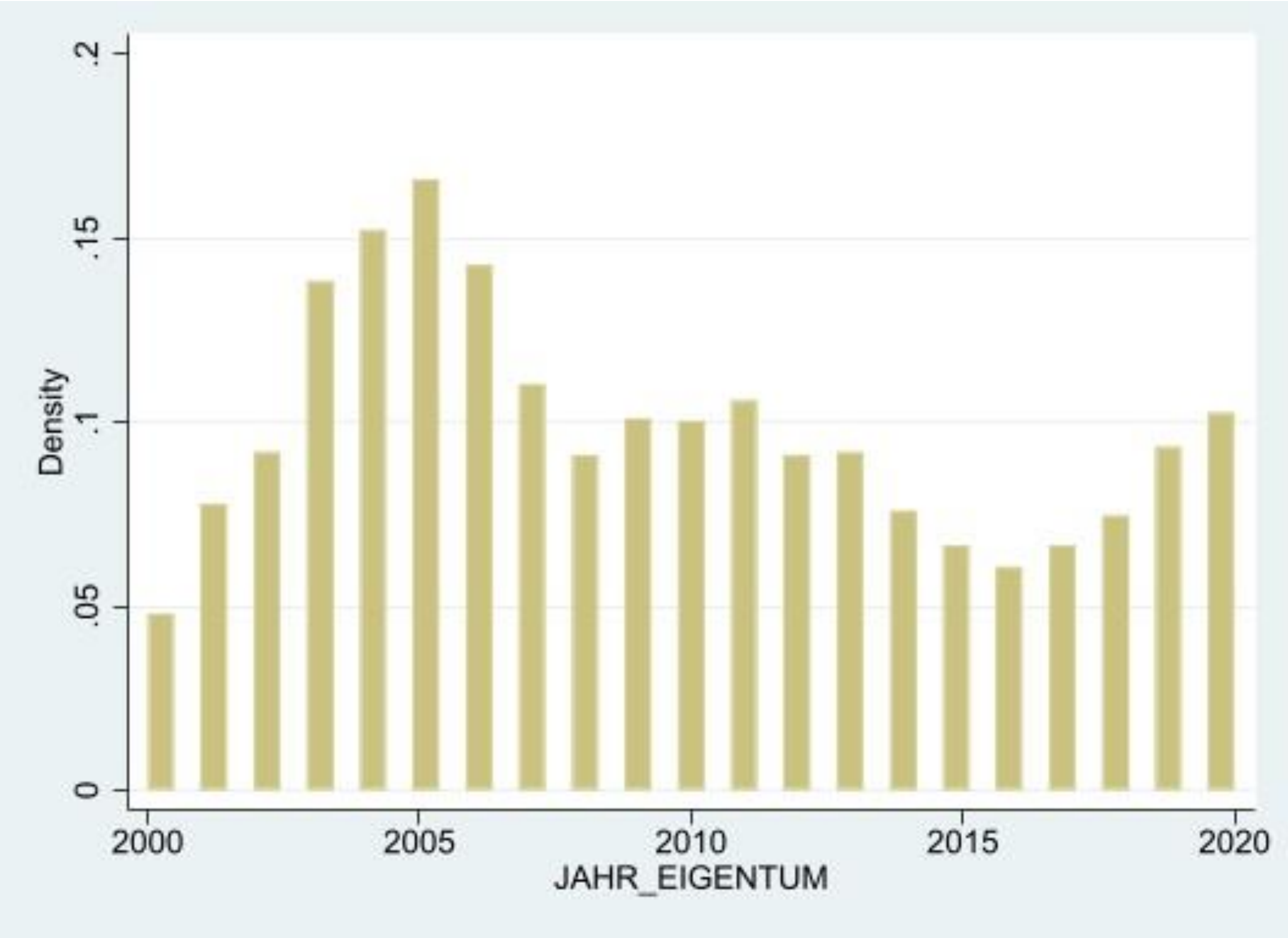
Dependent Variable:

- Real Transaction Price
  - Condominiums only: residences in a building with >1 dwellings
  - Primary (37.1%) and Secondary residences (62.9%)

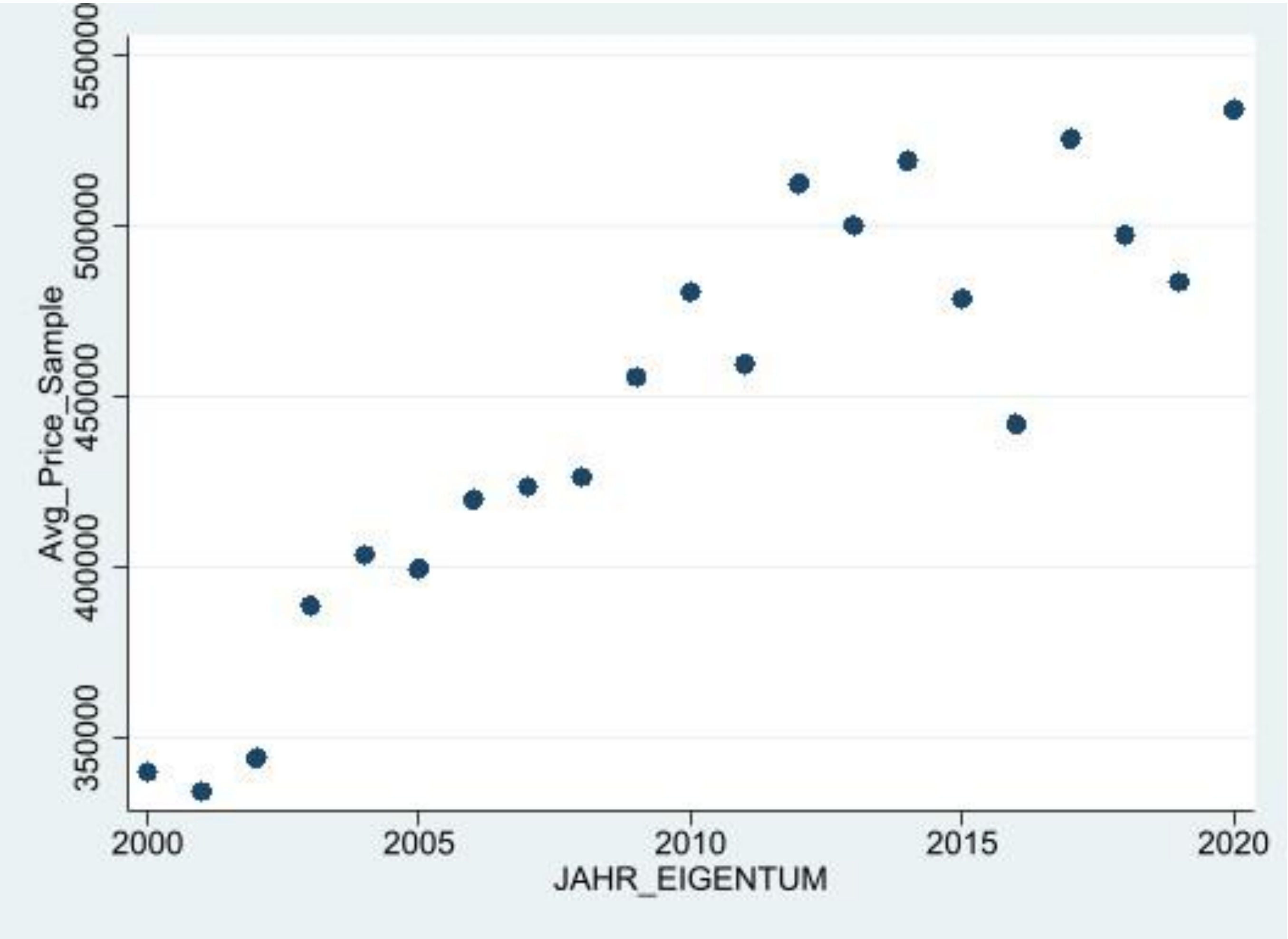
Independent variables

1. Ski Resort, Major, Minor (<50km), or None
2. Snow cover duration as share of season length (November-April)
   - Real and Artificial

Transactions by Year



Mean Transaction Price (CHF) by Year



Is winter sport a valuable amenity?

$$\ln P_{i,m,t} = \beta_0 + \beta_1 Ski\ Resort_m + \beta_2 \boldsymbol{Z}_{S;i,m,t} + \beta_3 \boldsymbol{Z}_{Local;m,t} + \beta_4 \boldsymbol{Z}_{Climate;m,t} + FE_t + FE_{Canton} + \varepsilon_{i,t}$$

$P_{i,m,t}$ is the price of house i in municipality m at time t
$Ski\ Resort_m$ is a dummy indicating whether municipality m is part of a ski resort
$\boldsymbol{Z}_{S;i,m,t}$ is a vector of structural (house) characteristics
$\boldsymbol{Z}_{Local;m,t}$ is a vector of municipality characteristics
$\boldsymbol{Z}_{Climate;m,t}$ is a vector of climatic conditions <u>at the municipal level</u>

Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Transaction Price	14128	645831	507160	100000	4640000
Resort (Major)	14128	0,850	0,357	0	1
Grand Hotel	14128	0,342	0,474	0	1
Age of building	14128	20,850	22,132	0	171
Square footage	14128	83,845	34,503	30	250
# Rooms	14128	3,159	1,107	1	10
# Baths	14128	1,653	0,594	1	4
Garage	14128	0,681	0,466	0	1
Micro-location	14128	-	-	1	4
Quality	14128	-	-	1	4
Structural state	14128	-	-	1	4
Avg. Summer Temperature	14128	14,393	1,921	9,893	20,787
Avg. Winter Temperature	14128	-2,276	2,262	-8,360	3,020
Sunshine Hours/month	14128	154,218	8,173	133,577	168,344
Distance Airport (minutes)	14128	129,681	27,713	71	211
Railway Station	14128	0,754	0,431	0	1
Peri-Urban	14128	0,047	0,213	0	1

Model	Major	Major FE	Minor	Minor FE
Dependent Variable	Ln(Real Price)	Ln(Real Price)	Ln(Real Price)	Ln(Real Price)
Resort (Major)	0.253***	0.243***		
	(-0.056)	(0.045)		
Resort (Minor)			0.162	0.179**
			(0.087)	(0,061)
Grand Hotel	0.150**	0.108	0.176**	0.128*
	(0.053)	(0.056)	(0.056)	(0.06)
Ln(Altitude)	0.113	-0.349	0.2	-0.183
	(0.171)	(0.208)	(0.172)	(0.231)
Ln(Dist. Airport)	0.374**	0.247	0.285*	0.155
	(0.127)	(0.207)	(0.138)	(0.223)
Railway Station	0.018	-0.004	0.034	0.037
	(0.056)	(0.046)	(0.062)	(0.052)
Ln(Summer Temp.)	-0.208	-0.84	-0.101	-0.661
	(0.427)	(0.633)	(0.439)	(0.67)
Ln(Winter Temp.)	0.013	-0.003	0.013	0.001
	(0.031)	(0.032)	(0.034)	(0.036)
Ln(Sunshine)	-0.112	2.232**	-0.066	2.301**
	(0.477)	(0.689)	(0.524)	(0.794)
Constant	6.567**	0.359	5.910*	-1.125
N	14128	14128	14128	14128
FE	no	Year & Canton	no	Year & Canton
R^2	0.693	0.819	0.685	0.809

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

SE clustered by Municipality

Primary vs. Secondary Residences

Model	**Interaction**
Dependent Variable	Ln(Real Price)
Major*Primary	0.240***
	(0.042)
Major*Secondary	0.359***
	(0.04)
None*Secondary	0.137***
	(0.028)
Constant	0.066
N	14128
FE	Year & Canton
R^2	0.826

* p<0.05, ** p<0.01, *** p<0.001 SE clustered by Municipality

Is winter sport a valuable amenity?

A house located in a municipality that is located within a major ski resort is worth 24.3% (15.5-33.2%) more than comparable houses elsewhere in the Swiss Alps.

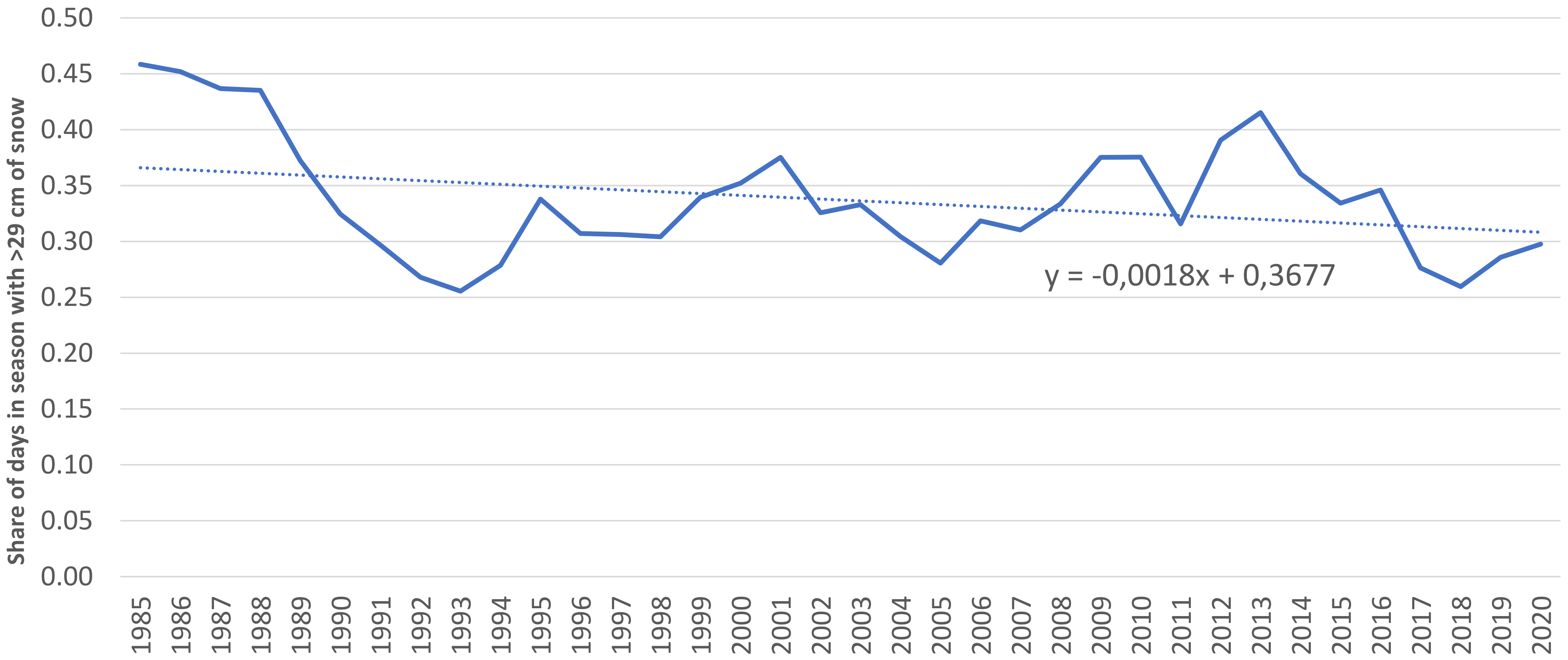
The premium associated with being by a minor ***or*** *major resort is estimated to be 17.9% (5.8-30.1%).*

Estimated premium is bigger for secondary residences but this difference is not significant.

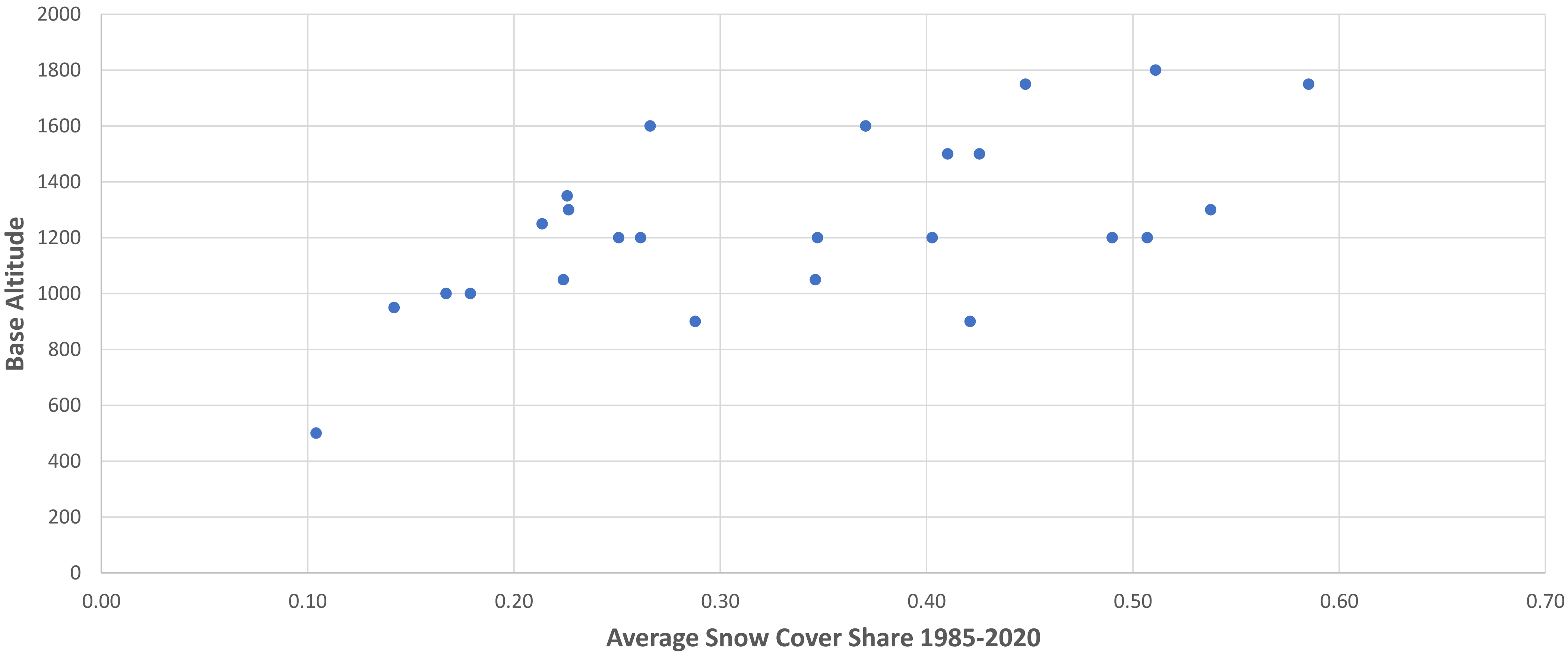
Snow Cover Duration

- Share of days in Winter with >30cm of snow.
  - Minimum needed for alpine skiing
- Data from Matiu et al. (2021)
  - Gapfilled data from MeteoSwiss
- Environmental lapse rate of 5cm/100m (Bühler et al., 2018)
- Only places with complete observations included 2000-2020
- 5-Year moving averages
- Measured at base altitude
  - Means that it is possible to ski everywhere

Snow cover trend (1985-2020)



Ski resort Altitudes and SCD



Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Ln(Price)	9658	12,906	0,662	11,108	15,007
Grand Hotel	9658	0,433	0,496	0	1
Ln(Altitude)	9658	7,182	0,237	6,240	7,565
Ln(Dist. Airport)	9658	4,858	0,211	4,331	5,193
Railway Station	9658	0,754	0,431	0	1
Ln(Winter Temp.)	9658	2,413	0,104	2,159	2,705
Ln(Summer Temp.)	9658	-1,155	0,687	-2,029	1,397
Ln(Sunshine)	9658	5,040	0,054	4,900	5,126
Good Position	9658	0,870	0,336	0	1
Ln(Age)	9658	2,337	1,489	0	5,147
Ln(Square footage)	9658	4,370	0,410	3,401	5,517
Ln(# Rooms)	9658	1,394	0,274	0,693	2,398
Ln(# Baths)	9658	0,960	0,226	0,693	1,609
Garage	9658	0,705	0,456	0	1
Micro-location	9658	-	-	1	4
Quality	9658	-	-	1	4
Structural state	9658	-	-	1	4
NSCD (Base level)	9658	0,341	0,153	0,008	0,696
NSCD (Median level)	6300	0,684	0,092	0,207	0,818
ASCD (Base level)	9658	0,260	0,108	0,041	0,497
Ln(Min. Alt.)	9658	7,164	0,226	6,215	7,467
Ln(Median Alt.)	9658	7,669	0,114	7,226	7,919
Ln(Max Alt.)	9658	7,997	0,103	7,696	8,269
Ln(Vert. Drop)	9658	7,394	0,219	6,802	7,741
Ln(Slope Length)	9658	5,254	0,489	3,689	5,858
Crowdedness	9658	247,398	54,369	134	400

Is there a Snow Cover-Premium?

$$\ln P_{i,m,j,t} = \beta_0 + \beta_1 SCD_{j,t} + \beta_2 \boldsymbol{Z}_{S;i,m,t} + \beta_3 \boldsymbol{Z}_{Ski;j,t} + \beta_4 \boldsymbol{Z}_{Local;m,t} + \beta_5 \boldsymbol{Z}_{Climate;m,t} + FE_t + FE_{Canton} + \varepsilon_{i,t}$$

$P_{i,m,j,t}$ is the price of house i in municipality m in ski resort j at time t
$SCD_{j,t}$ is the share of days with >30cm snow cover
$\boldsymbol{Z}_{S;i,m,t}$ is a vector of structural (house) characteristics
$\boldsymbol{Z}_{Ski;j,t}$ is a vector of ski resort characteristics
$\boldsymbol{Z}_{Local;m,t}$ is a vector of municipality characteristics
$\boldsymbol{Z}_{Climate;m,t}$ is a vector of climatic conditions at the municipal level

Model	Real Price	Real Price FE	Detrended Price	Inter-temporal
Dependent Variable	Ln(Real Price)	Ln(Real Price)	Ln(Relative Price)	Ln(Relative Price)
NSCD (share)	0.296***	0.464***	0.201***	-0,087
	(0.043)	(0.051)	(0.044)	(0.053)
Ln(Altitude)	0.867***	0.355***	0,106	0,11
	(0.073)	(0.078)	(0.059)	(0.071)
Ln(Summer Temp.)	0.677***	0.639***	-0,014	-0.329**
	(0.131)	(0.163)	(0.111)	(0119)
Ln(Winter Temp.)	0.050***	-0.024**	-0,01	-0.014*
	(0.009)	(0.008)	(0.007)	(0.007)
Good Position	0.048***	0.214***	0.224***	0.193***
	(0.014)	(0.012)	(0.012)	(0.012)
Ln(Vert. Drop)	4.658***	2.528*	-0,381	
	(0.471)	(0.992)	(0.978)	
Ln(Slope Length)	0.286***	0.091***	0.103***	
	(0.012)	(0.011)	(0.011)	
Constant	10.650***	-13.528***	-16.355***	5.640**
N	9658	9658	9658	9658
FE	No	Year & Canton	Canton	Resort
R^2	0,736	0,848	0,846	0,853

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

Robust SE

Is there a Snow Cover-Premium?

A one percentage-point increase in the snow cover duration-share is associated with 0.464 percent (0.363-0.564%) increase in house prices

When using Resort-FE instead of Time-FE the estimates are insignificant → cross sectional variation in snow cover duration explains cross-sectional variation in transaction prices. Inter-temporal variation in snow cover duration does not explain inter-temporal variation in transaction prices.

This makes sense: relative climatic differences are much bigger across space than across time!

Artificial Snow

- Artificial snow can be produced at an air temperature of –3°C to –4°C and average humidity
  - Just 20 cm required due to higher density
- Data from MeteoSwiss
- Following Steiger and Mayer (2008), I define a snowmaking day as a day with an average temperature not exceeding -2°C.
  - Adjusting for altitude is easier here
- Artificial SCD is defined as the share of days in the season with an average temperature <= -2°C
- 5-Year moving averages

Model	**Real Price**	**Real Price FE**	**Detrended Price**
Dependent Variable	Ln(Real Price)	Ln(Real Price)	Ln(Relative Price)
NSCD (share)	0.278***	0.426***	0.184***
	(0.042)	(0.052)	(0.044)
ASCD (share)	0.803***	-0.379***	-0.363***
	(0.803)	(-0.379)	(-0.363)
Ln(Altitude)	1.203***	0,154	-0,061
	(0.076)	(0.097)	(0.072)
Ln(Summer Temp.)	1.148***	0.379*	-0,185
	(0.134)	(0.178)	(0.117)
Ln(Winter Temp.)	0.088***	-0.033***	-0.024***
	(0.009)	(0.008)	(0.007)
Good Position	0.052***	0.221***	0.228***
	(0.014)	(0.012)	(0.012)
Ln(Vert. Drop)	3.915***	2.823**	0,18
	(0.475)	(0.992)	(0.978)
Ln(Slope Length)	0.282***	0.094***	0.104***
	(0.012)	(0.011)	(0.011)
Constant	10.433***	-14.173***	-16.641***
N	9658	9658	9658
FE	No	Year & Canton	Canton
R^2	0,739	0,848	0,846

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

Robust SE

Artificial and Real Snow

Inclusion of ASCD does not change the estimates for NSCD → robust results

The value of ASCD is negative after controlling for time, how can this be?

- *Could be measurement error, ASCD might not be constructed correctly. I am not actually measuring ASCD but # days with average temperature <= -2°C → not the same thing!*
- *Proliferation of snow making equipment is a recent phenomenon, I might be wrong in assuming that the equipment is there for all periods.*
- *Agents might not be aware of ASCD like they are of NSCD*

Climate Change

- Why not simply look at the trajectory of SCD and house prices over the past 20 year?

  → SCD has actually been steady since 1989

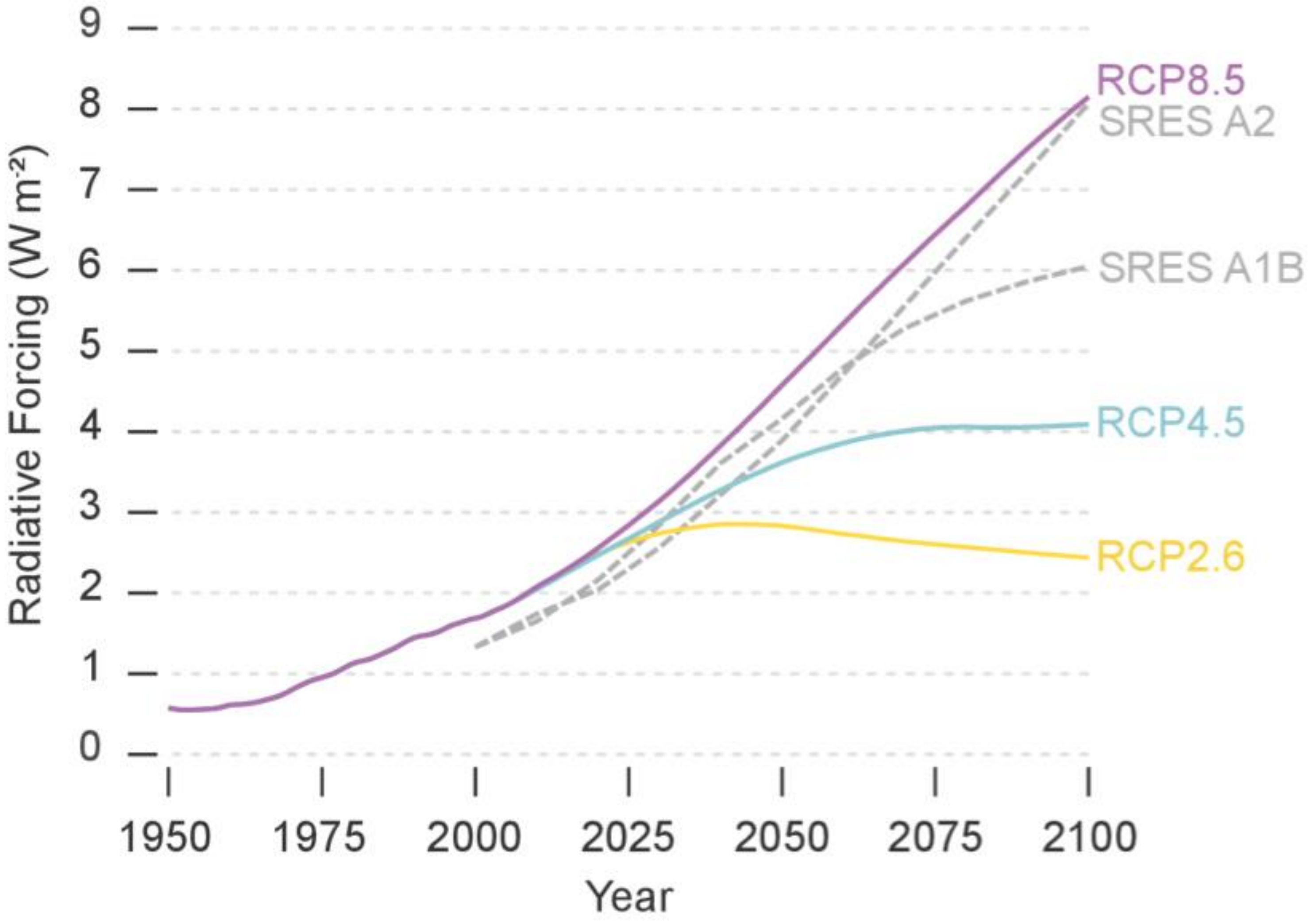
  → limited relative change between places

- Look at predicted climate change instead

  → Discount the future:

$$\boldsymbol{Z}_0 = \boldsymbol{z}_0 + \frac{\mathrm{E}_1[\boldsymbol{z}]}{(1+r_1)} + \frac{\mathrm{E}_2[\boldsymbol{z}]}{(1+r_2)^2} + \frac{\mathrm{E}_3[\boldsymbol{z}]}{(1+r_3)^3} + \cdots + \frac{\mathrm{E}_\mathrm{T}[\boldsymbol{z}]}{(1+r_T)^T}$$

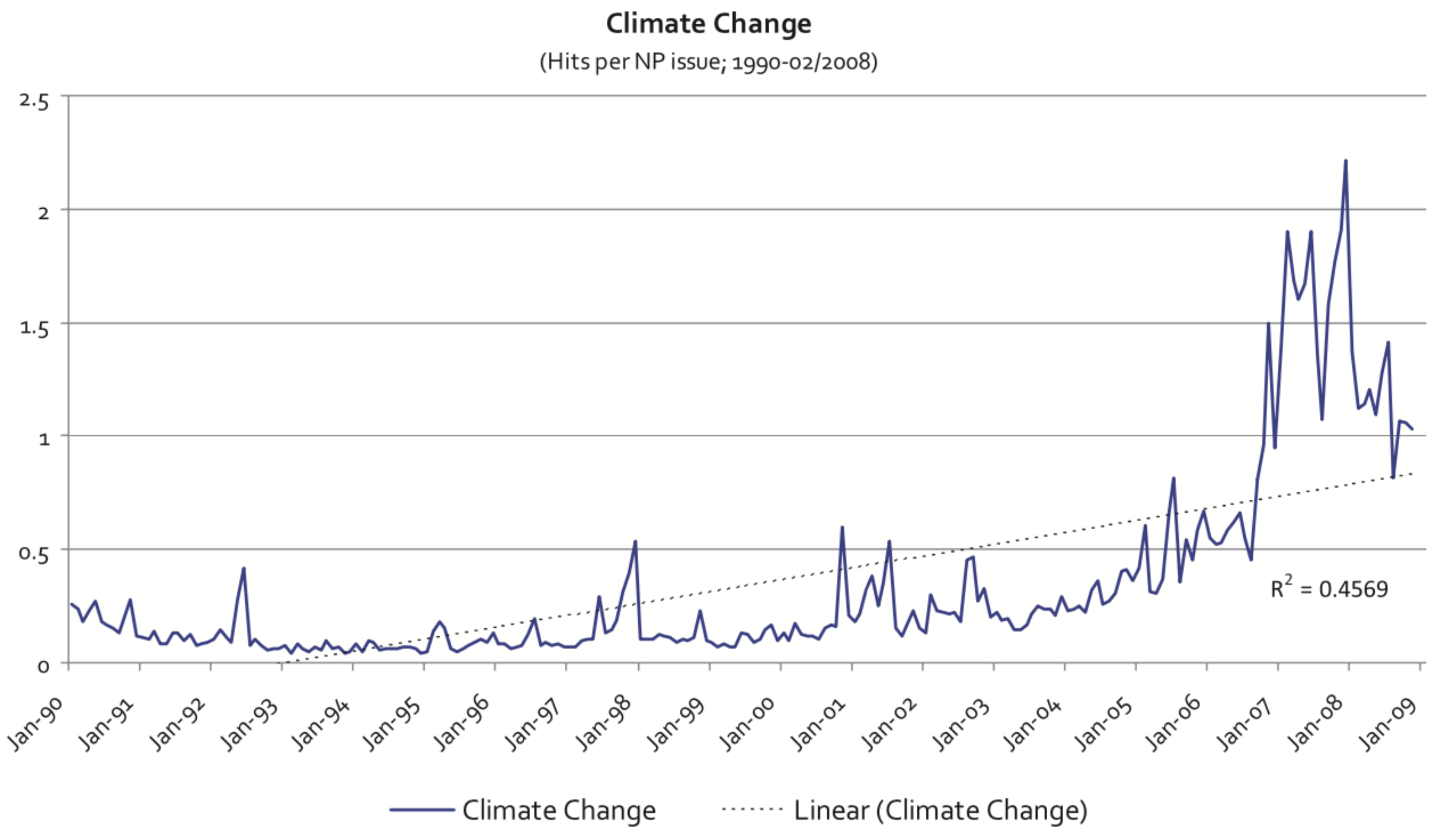
Emission pathways



Identification

- Use the PV of all future flows as the independent variable of interest
  - Assume other amenities do not change over time
- Add an index of climate attention
- Show differential impact for differentially affected properties
  - Primary vs. Secondary residences → no big difference
  - Distance from the slopes → exact locations required

Climate Change Attention



Coverage of climate change in worldwide sample of newspapers. Source: Holt and Barkemeyer (2012).

Other factors

- (Global) Demand for skiing
- Visitor numbers/overnight stays
- Other activities
- Supply-side factors

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