Highways, Market Access, and Spatial Sorting

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Motivation

Expansion of transportation networks

- Expand location choices of workers and residents
- Allow for commuting

→ **Sorting** of heterogeneous individuals

→ Urban **sprawl**

What we do – Theory

Design a reduced form spatial equilibrium model featuring

- **Commuting** and commuting costs
  - as in Monte, Redding, Rossi-Hansberg (*forthcoming*)
- **Sorting** of heterogeneous individuals across heterogeneous locations

What we do – Empirics

Estimate effects of Highway Access on

- **Size**: Number of residents and number of workers
- **Composition**: Income and skill distributions
- **Commuting** and urban **sprawl**

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Identification:

- Swiss **non-urban** municipalities
- Use variation over time ('**within**')
- Deviations from
  - Municipality-specific time trends
  - Countrywide macro shocks

What we find – Theory

Highway access

- Raises attractiveness of a municipality
- Improves **Commuting Access**
  - → Attracts residents
  - → Attracts firms and workers

Effect is stronger for the higher skilled

What we find – Empirics

Long-term impact of Highway Access on

1. Municipality **size**:
   - +12% residents (#taxpayers)
   - +6% employment

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   - −7% low-income taxpayers (below median)
   - +23% high-income taxpayers (top 10%)
   - +20% highly-educated workers (university degree)

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3. **Commuting**:
   - +43% share high-skilled in-commuters
   - +21% share high-skilled out-commuters

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3. **Commuting**:
   - +43% share high-skilled in-commuters
   - +21% share high-skilled out-commuters
4. **Sprawl**:
   - Decentralization of jobs and residences
   - More pronounced for high-skilled

Why should we care?

Transportation infrastructures are costly (Redding Turner 2015)

- US Interstate Construction Program $128.9 billion (1991 USD)
- Chinese National Trunk Highway System: $120 billion (current USD)
- 20% of World Bank lending (Baum-Snow Henderson Turner Zhang Brandt 2018)
- May not be cost effective (Duranton Turner 2012, Gonzalez-Navarro Turner 2018)

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Highways shape the economic geography

- Sub-urbanization of US population 1950-90 (Baum-Snow 2007)
- Sub-urbanization of US jobs 1960-2000 (Baum-Snow 2010)
- Sub-urbanization of population and jobs in China (Baum-Snow et al.)
- Sub-urbanization in Europe (Garcia-López Pasidis Viladecans-Marsal 2016)
- De-industrialization of peripheral Chinese counties (Faber 2014)
- Sector specialization of cities (Duranton Morrow Turner 2014)
- So do subways and other modes (Gonzalez-Navarro Turner 2018)

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Regional disparities: Sorting matters

- Urban premium (Combes Duranton Gobillon 2008, Davis Dingle 2018)
- Real vs. nominal wage inequality (Moretti 2013, Diamond 2016)
- Skill composition (Glaeser 2008, Glaeser Resseger Tobio 2009, Davis Dingle 2017)

Plan

Model

Workers and Geography

- Workers have heterogeneous abilities ('skills' s)
- Live in municipality n and works in municipality i

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Preferences and location choices

- Non-homothetic preferences
- Housing as income inelastic good
- Frechet idiosyncratic preferences over (n, i)
- Fraction of type s choosing pair (n, i):

$$\lambda_{nis} = \left(\frac{V_{nis}}{\mathbb{E}V_s}\right)^{\kappa}, \qquad V_{nis} = \frac{B_n B_i}{d_{ni}} \frac{w_s}{(q_n)^{1-\alpha}} \left(1 - h\frac{q_n}{w_s}\right)$$

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Implications

- High-B_n locations attract more people
- Command higher housing prices q_n
- Attract high-s residents disproportionately
- Highway connection of either i or n raises B_n or B_i

$\rightarrow$ $\uparrow$ Commuting Access attracts high-s types disproportionately

Qualitative predictions

Highway Access $\Rightarrow$

1. **Size**: Employment and #Residents increase.
2. **Composition:** Shift to the right to wage and skill distributions.
3. **Commuting:** Ambiguous but strongest in absolute value for highest skilled workers.
4. **Sprawl:** idem.

Plan

Data

Municipality employment, residence, and composition

- Swiss municipalities
- #Taxpaying units: Federal income statistics 1949-2010
- Residential-workplace pairs by education level: Census 1970, 80,...,2010

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Expansion of Highway Network

- Access points: Swiss Federal Office of Topography (VECTOR200)
- Opening dates: Swiss Federal Roads Office (ASTRA)
  - Fischer and Volk (1999)
  - Publicly available sources (newspaper articles, press releases)

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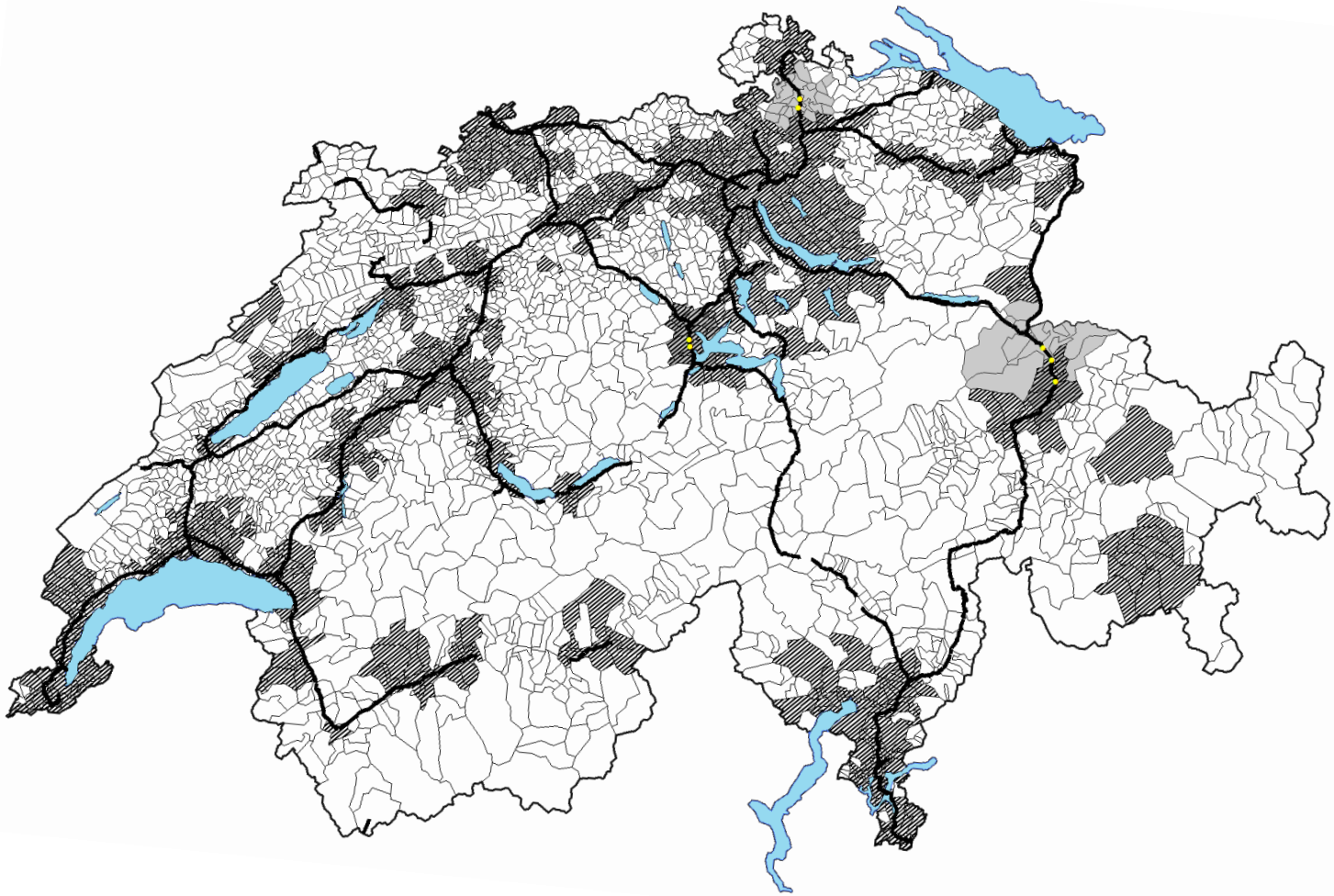
Auxiliary data

- Railway stops: Swiss Federal Office of Transport (FOT)

Table: Summary Statistics – Municipalities

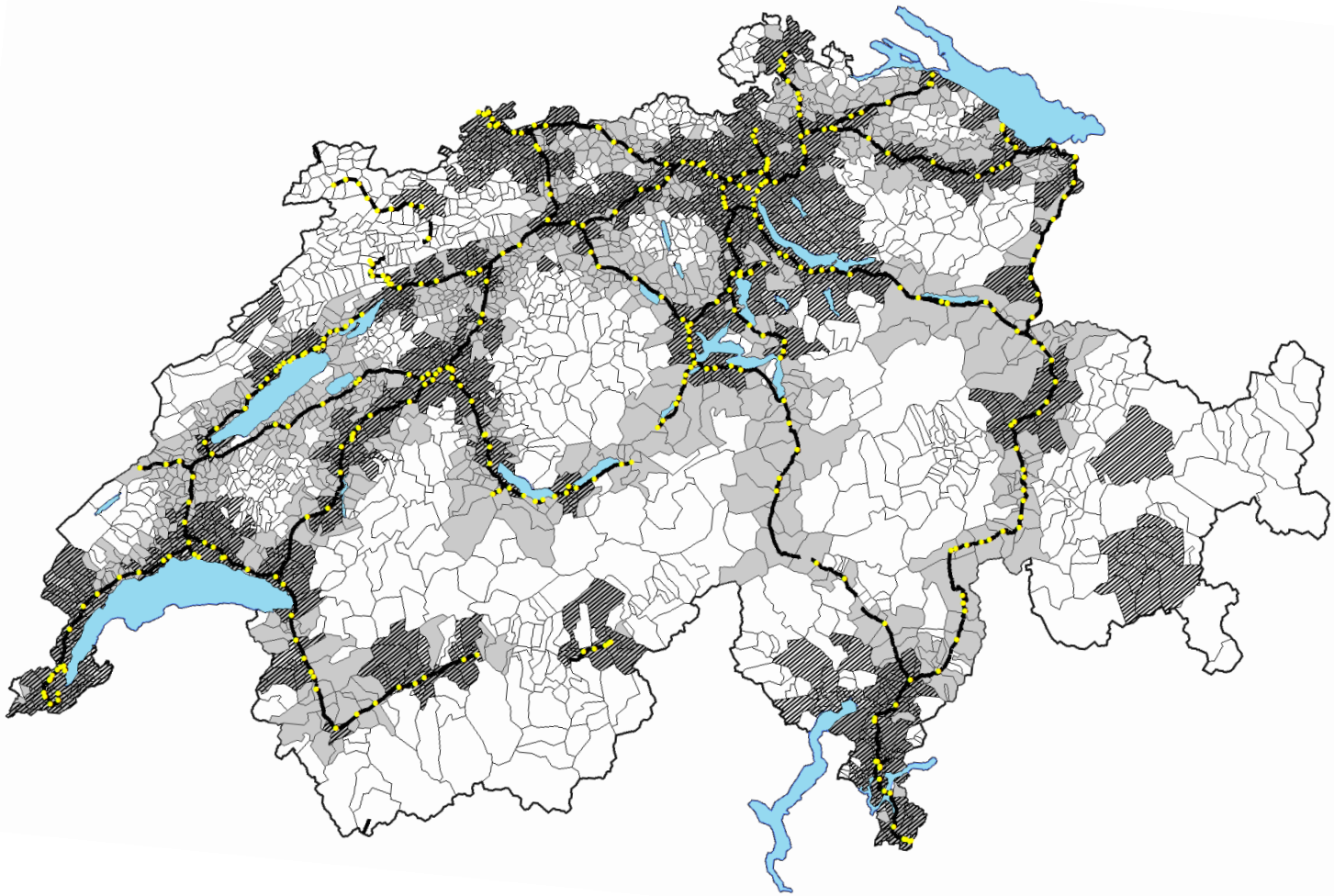
	All municipalities	Non-agglomeration municipalities	Non-agglomeration municipalities, access within 10 km	Urban centers
	(1)	(2)	(3)	(4)
Population (in 1,000)	2.73	1.14	1.18	64.10
	(10.72)	(1.42)	(1.47)	(75.48)
#Taxpayers (in 1,000)	0.83	0.31	0.33	25.41
	(4.04)	(0.47)	(0.49)	(31.99)
Share in bottom-50% income	0.57	0.61	0.59	0.50
	(0.12)	(0.11)	(0.10)	(0.06)
Share in 50-25% quartile	0.23	0.23	0.23	0.25
	(0.05)	(0.06)	(0.05)	(0.02)
Share in top-25-10%	0.12	0.11	0.11	0.15
	(0.05)	(0.05)	(0.05)	(0.02)
Share in top-10% decile	0.08	0.06	0.06	0.10
	(0.06)	(0.04)	(0.04)	(0.03)
#Workers (in 1,000)	1.25	0.43	0.43	48.83
	(8.15)	(0.69)	(0.72)	(65.60)
Share with low education	0.34	0.37	0.36	0.24
	(0.17)	(0.18)	(0.17)	(0.09)
Share with middle education	0.53	0.52	0.53	0.54
	(0.12)	(0.13)	(0.13)	(0.06)
Share with high education	0.13	0.11	0.12	0.22
	(0.09)	(0.09)	(0.09)	(0.11)
Railway station	0.39	0.34	0.34	1.00
	(0.49)	(0.47)	(0.47)	(0.00)

Figure: Municipalities with highway access in 1960



Note: Shaded areas denote municipalities that are part of an urban agglomeration area as defined by the Federal statistical office in 2000. Municipalities with highway access within 10km road distance are in light gray. Access points are in yellow.

Figure: Municipalities with highway access in 2010



Note: Shaded areas denote municipalities that are part of an urban agglomeration area as defined by the Federal statistical office in 2000. Municipalities with highway access within 10km road distance are in light gray. Access points are in yellow.

Plan

Identification

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- Network planned in 1960
- Aim: connect major cities (as in e.g. Faber 2014)
- Gradually developed over time (as in e.g. Donaldson 2018)
- Municipality-specific time trend

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Sample

- Municipalities that eventually get Highway Access within 10km
- (Also experiment with other distances)

Table: Summary Statistics – Timing

Mean values for period 1949-1955 for sample of municipalities

	All opening years (1)	Access opened before 1970 (2)	Access opened 1970-1990 (3)	Access opened after 1990 (4)	Test equality p-value
Population (in 1,000)	0.95	0.98	0.92	0.85	0.54
	(1.15)	(1.32)	(1.00)	(0.89)	
#Taxpayers (in 1,000)	0.16	0.18	0.15	0.15	0.42
	(0.25)	(0.30)	(0.21)	(0.20)	
#Taxpayers growth rate	-7.27	-6.93	-7.73	-6.43	0.18
	(30.29)	(29.00)	(31.37)	(29.93)	
Share in bottom-50% income	0.62	0.62	0.63	0.61	0.06
	(0.10)	(0.10)	(0.10)	(0.10)	
Share in 50-25% quartile	0.21	0.21	0.21	0.21	0.10
	(0.06)	(0.06)	(0.06)	(0.06)	
Share in top-25-10%	0.11	0.11	0.10	0.11	0.11
	(0.06)	(0.06)	(0.06)	(0.06)	
Share in top-10% decile	0.06	0.07	0.06	0.06	0.12
	(0.04)	(0.05)	(0.04)	(0.04)	
#Workers (in 1,000)	0.37	0.38	0.37	0.32	0.55
	(0.51)	(0.62)	(0.43)	(0.38)	
#Residents (in 1,000)	0.40	0.43	0.39	0.35	0.39
	(0.49)	(0.59)	(0.42)	(0.37)	
Railway station	0.33	0.29	0.35	0.40	0.13
	(0.47)	(0.46)	(0.48)	(0.49)	
# Municipalities	782	313	386	83	-

Identification (cont.)

Specification

$$\ln n_{i,t} = \gamma \, Access_{i,t} + \sum_{\tau=1}^{10} \beta_\tau \left(Access_{i,t-\tau} - Access_{i,t} \right) + \alpha_i + \rho_i \, t + \lambda_t + \varepsilon_{i,t}$$

- γ: Long term effect (variable of interest)
- $\{\beta_\tau\}$: Transition effects

Identification (cont.)

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Within Estimator – deviation from

- time invariant characteristics: α_i
- individual time trend: ρ_i
- countrywide macro shocks: λ_t (two different ones)
  - municipalities endowed with a railway station
  - without a railway station

Plan

Municipality Size (1) and Composition (2) – Taxpayers

Table: Impact of highway access on number and composition of taxpayers

	Municipalities not part of urban agglomeration areas, access within 10 km					
	# Taxpayers		Share of taxpayers by income quantile			
			below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)	(6)
Long-term effect ($\hat{\gamma}$)	0.100***	0.111***	-0.070***	0.065***	0.184***	0.208***
	(0.024)	(0.018)	(0.011)	(0.017)	(0.027)	(0.046)
10 periods lag included	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Municipality time trends	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	(Yes)	No	No	No	No
Year-rail fixed effects	No	Yes	Yes	Yes	Yes	Yes
# Observations	23243					
# Municipalities	780					

Municipality Size (1) and Composition (2) – Taxpayers (cont.)

Results

- Positive effect on size
- Right-shift of the income distribution

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Possible mechanisms

- Heterogeneous effect on earnings or income sorting?
- Residential or job mobility?

Municipality Size (1) and Composition (2) – Taxpayers (cont.)

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Census data

- Residents and Workers by education level

→ Commuting and Sprawl

- But shorter panel (1970-2010)

(3) Commuting – Census

Table: Impact of highway access on commuting

	# Employees		Share of employees by education level		
			low	middle	high
	(1)	(2)	(3)	(4)	(5)
Panel C: Out-commuters					
Long-term effect ($\hat{\gamma}$)	0.015	0.001	-0.001	-0.079**	0.191**
	(0.036)	(0.038)	(0.059)	(0.033)	(0.083)
# Observations	5197	3602	3602	3602	3602
# Municipalities	782	771	771	771	771
Panel D: In-commuters					
Long-term effect ($\hat{\gamma}$)	0.146*	0.080	0.087	-0.122**	0.359**
	(0.081)	(0.090)	(0.094)	(0.054)	(0.156)
# Observations	4901	2722	2722	2722	2722
# Municipalities	779	661	661	661	661

(4) Sprawl – Census

Table: Impact of highway access on urban sprawl (27 cities)

	# Employees		Share of employees by education level		
			low	middle	high
	(1)	(2)	(3)	(4)	(5)
Panel C: Out-commuters					
Long-term effect (center)	-0.213**	-0.245**	1.170***	-0.274***	-0.741***
	(0.085)	(0.102)	(0.148)	(0.067)	(0.122)
	(0.085)	(0.102)	(0.148)	(0.067)	(0.122)
Long-term effect ($\leq$ 20 km)	0.026	-0.008	0.056	-0.119***	0.061
	(0.036)	(0.041)	(0.053)	(0.025)	(0.065)
Long-term effect (21-40 km)	0.168***	0.030	0.009	-0.060*	0.091
	(0.044)	(0.047)	(0.067)	(0.036)	(0.085)
Long-term effect (>40 km)	0.258**	0.023	0.137	-0.019	0.147
	(0.111)	(0.121)	(0.161)	(0.073)	(0.221)
# Observations	10257	7307	7307	7307	7307
# Municipalities	1528	1517	1517	1517	1517

(4) Sprawl – Census (cont.)

Table: Impact of highway access on employment size and composition (27 cities)

	# Employees		Share of employees by education level		
			low	middle	high
	(1)	(2)	(3)	(4)	(5)
Panel D: In-commuters					
Long-term effect (center)	-0.150*	-0.194*	-0.364***	-0.039	0.123
	(0.079)	(0.105)	(0.138)	(0.059)	(0.146)
Long-term effect ($\leq$ 20 km)	0.137*	0.138*	0.071	-0.099***	0.306***
	(0.070)	(0.073)	(0.073)	(0.037)	(0.115)
Long-term effect (21-40 km)	0.186*	0.051	0.095	-0.072	0.375**
	(0.095)	(0.091)	(0.089)	(0.051)	(0.146)
Long-term effect (>40 km)	0.252	-0.142	0.270	-0.159	0.430
	(0.221)	(0.179)	(0.189)	(0.102)	(0.302)
# Observations	9890	6180	6180	6180	6180
# Municipalities	1525	1391	1391	1391	1391

Plan

Robustness Checks and Additional Specifications

Robustness checks

- Size and Composition effects: census data CENSUS
- Placebo test for opening years PLACEBO
- Include all non-urban municipalities (diff-in-diff) DiD

Additional specifications

- Railway stations RAIL
- Initial conditions RESIDENTS/WORKERS EMPLOYMENT IN SECTOR II
- Distance to urban centers DIST
- Opening period OPEN
- Heterogeneous effects HETERO
- Impact over time and leads LEADS

Plan

Summary and Conclusions

Highways matter

1. Size
   - +12% residents/taxpayers
2. Composition: Sorting matters!
   - −7% share of below-median taxpayers
   - +20% share of workers with university degrees
3. Commuting
   - +43% share of in-commuters with university degree
   - +21% share of out-commuters with university degree
4. Sprawl
   - Suburbanization of jobs and residences
   - High-skill jobs least affected
   - High-skill residents move out of city centres

Highways contribute to **sub-urbanization of residences and jobs**

→ Implications for spatial disparities and tax competition.

Appendix

Appendix – Size and Composition Effects: Census Data

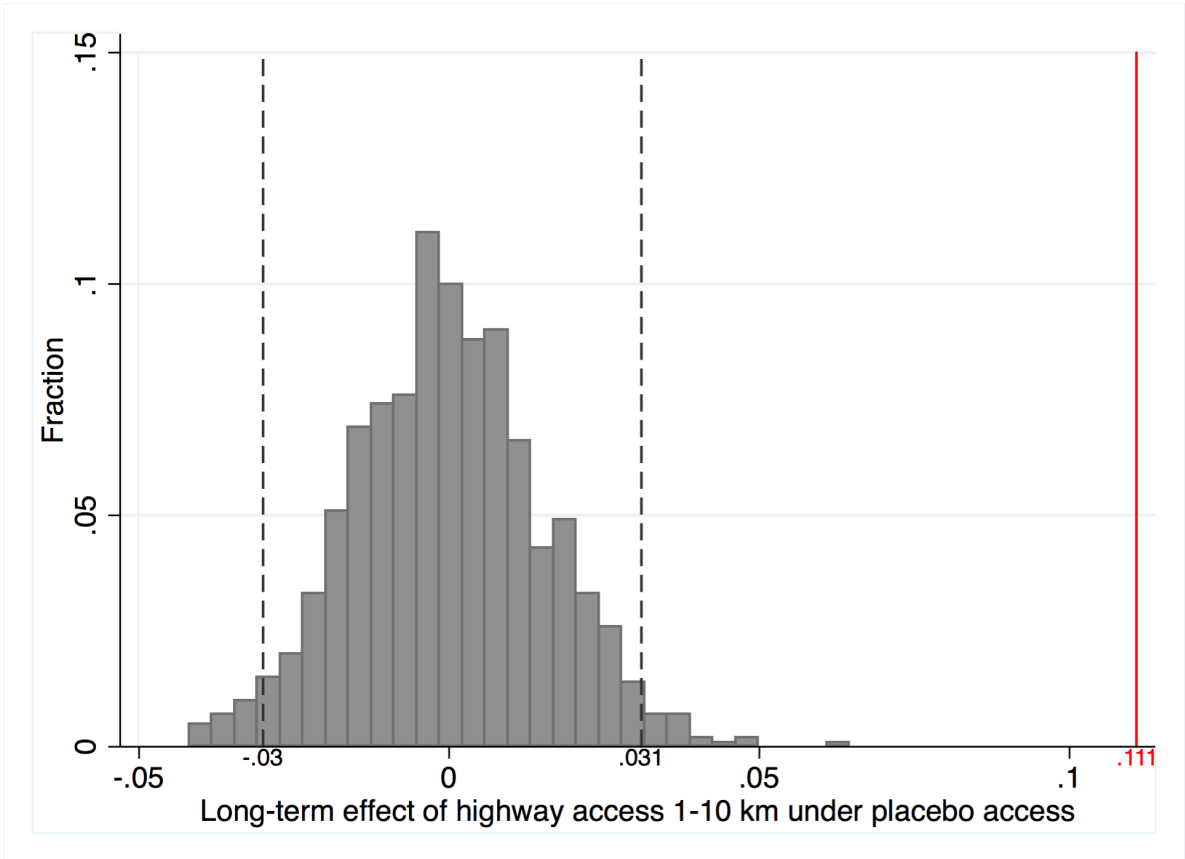
Table: Impact of highway access on employment size and composition

	# Employees		Share of employees by education level		
			low	middle	high
	(1)	(2)	(3)	(4)	(5)
Panel A: Residents					
Long-term effect ($\hat{\gamma}$)	0.075***	0.001	-0.016	-0.085***	0.103
	(0.022)	(0.037)	(0.047)	(0.029)	(0.077)
# Observations	5201	3750	3750	3750	3750
# Municipalities	782	781	781	781	781
Panel B: Workers					
Long-term effect ($\hat{\gamma}$)	0.049	0.025	0.085	-0.101***	0.181**
	(0.034)	(0.052)	(0.059)	(0.037)	(0.083)
# Observations	5114	3568	3568	3568	3568
# Municipalities	782	771	771	771	771

BACK

Appendix – Placebo

Figure: Effect on the number of taxpayers - placebo test



Note: Highway access opening date randomized 1000 times. Dashed lines show the implied estimate for which an effect is statistically significant at a 5% significance level. Red line is the coefficient from the baseline regression.

BACK

Appendix – Diff-in-diff

Table: Impact of highway access on number and composition of taxpayers

	No taxpayers		Share of taxpayers			
			below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)	(6)
Long-term ($\hat{\gamma}$)	0.079***	0.110***	-0.066***	0.047***	0.190***	0.239***
	(0.021)	(0.017)	(0.010)	(0.016)	(0.026)	(0.047)
10 periods lag included	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Municipality time trends	No	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	No	No	No	No	No
Year-rail fixed effects	No	Yes	Yes	Yes	Yes	Yes
# Observations	40537					
# Municipalities	1389					

BACK

Appendix – Railway

Table: Impact of highway access on tax base - Interaction with railway access

	No taxpayers	Share of taxpayers			
		below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)
Long-term effect (no rail)	0.116***	-0.068***	0.064***	0.196***	0.287***
	(0.024)	(0.014)	(0.023)	(0.038)	(0.064)
Long-term effect (rail)	0.102***	-0.074***	0.067***	0.160***	0.065
	(0.025)	(0.015)	(0.021)	(0.033)	(0.059)
# Observations			23243		
# Municipalities			780		

BACK

Appendix – Initial Conditions: Residents/Workers

Table: Impact of highway access on tax base - Interaction with 1949 ratio residents/workers

	No taxpayers	Share of taxpayers			
		below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)
Long-term effect ($\hat{\gamma}$)	0.119***	-0.064***	0.058***	0.169***	0.157***
	(0.019)	(0.011)	(0.017)	(0.027)	(0.045)
Long-term effect $\times$	-0.123	-0.104**	0.142**	0.336**	0.170
$[\ln(ratio_i) - \ln(ratio_{median})]$	(0.079)	(0.049)	(0.071)	(0.131)	(0.286)
# Observations			20423		
# Municipalities			655		

BACK

Appendix – Initial Conditions: Residents/Workers (cont.)

Table: Impact of highway access on commuting - Interaction with 1949 ratio residents/workers

	# Employees		Share of employees by education level		
			low	middle	high
	(1)	(2)	(3)	(4)	(5)
Panel C: Out-commuters					
Long-term effect ($\hat{\gamma}$)	0.056	0.044	0.038	-0.096**	0.183*
	(0.038)	(0.047)	(0.071)	(0.041)	(0.096)
Long-term effect × $[\ln(ratio_i) - \ln(ratio_{median})]$	-0.082	-0.244	0.073	0.047	0.534
	(0.159)	(0.169)	(0.251)	(0.124)	(0.325)
# Observations	4693	3124	3124	3124	3124
# Municipalities	681	671	671	671	671
Panel D: In-commuters					
Long-term effect ($\hat{\gamma}$)	0.092	0.010	0.045	-0.069	0.300*
	(0.085)	(0.109)	(0.115)	(0.062)	(0.176)
Long-term effect × $[\ln(ratio_i) - \ln(ratio_{median})]$	0.060	0.884**	0.186	-0.061	-0.328
	(0.321)	(0.374)	(0.375)	(0.215)	(0.619)
# Observations	4400	2304	2304	2304	2304
# Municipalities	678	565	565	565	565

BACK

Appendix – Initial Conditions: Sector II Employment Share

Table: Impact of highway access on tax base - Interaction with 1955 share of employment in secondary sector

	No taxpayers	Share of taxpayers			
		below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)
Long-term effect ($\hat{\gamma}$)	0.095***	-0.073***	0.070***	0.182***	0.182***
	(0.018)	(0.011)	(0.016)	(0.027)	(0.047)
Long-term effect $\times$	-0.068*	0.007	-0.046	-0.007	-0.187
$[\ln(ratio_i) - \ln(ratio_{median})]$	(0.038)	(0.029)	(0.047)	(0.065)	(0.140)
# Observations			22245		
# Municipalities			723		

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Appendix – Initial Conditions: Sector II Employment Share (cont.)

Table: Impact of highway access on commuting - Interaction with 1955 share of employment in secondary sector

	# Employees		Share of employees by education level		
			low	middle	high
	(1)	(2)	(3)	(4)	(5)
Panel C: Out-commuters					
Long-term effect ($\hat{\gamma}$)	-0.009	-0.016	-0.000	-0.082**	0.211**
	(0.037)	(0.038)	(0.060)	(0.033)	(0.085)
Long-term effect $\times$ $[\ln(ratio_i) - \ln(ratio_{median})]$	-0.145*	-0.211**	0.013	-0.020	0.117
	(0.078)	(0.087)	(0.135)	(0.064)	(0.154)
# Observations	5017	3526	3526	3526	3526
# Municipalities	754	748	748	748	748
Panel D: In-commuters					
Long-term effect ($\hat{\gamma}$)	0.101	0.073	0.079	-0.126**	0.347**
	(0.079)	(0.089)	(0.094)	(0.054)	(0.152)
Long-term effect $\times$ $[\ln(ratio_i) - \ln(ratio_{median})]$	-0.330**	-0.287	-0.084	-0.164	0.213
	(0.166)	(0.277)	(0.224)	(0.151)	(0.319)
# Observations	4790	2704	2704	2704	2704
# Municipalities	753	655	655	655	655

Appendix – Distance to urban centers

Table: Impact of highway access on tax base - Interaction with distance to city centers

	No taxpayers	Share of taxpayers			
		below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)
Long-term effect ($<$ 20 km)	0.040*	-0.078***	0.106***	0.173***	0.171**
	(0.021)	(0.016)	(0.025)	(0.040)	(0.077)
Long-term effect ($\geq$ 20 km)	0.173***	-0.053***	0.027	0.191***	0.234***
	(0.027)	(0.014)	(0.023)	(0.038)	(0.060)
# Observations			23018		
# Municipalities			765		

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Appendix – Opening period

Table: Impact of highway access on tax base - Interaction with highway opening period

	No taxpayers	Share of taxpayers			
		below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)
Long-term effect (before 1971)	0.158***	-0.016	-0.013	0.125	0.308*
	(0.056)	(0.030)	(0.045)	(0.083)	(0.169)
Long-term effect (after 1971)	0.144***	-0.011	0.012	-0.028	-0.134
	(0.024)	(0.016)	(0.027)	(0.049)	(0.088)
# Observations			23018		
# Municipalities			765		

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Appendix – Heterogeneous Effects

Table: Impact of highway access on tax base - Distance bands

	No taxpayers	Share of taxpayers			
		below 50%	top 50%-25%	top 25%-10%	top 10%
	(1)	(2)	(3)	(4)	(5)
Long-term (0-5 km)	0.099***	-0.059***	0.009	0.137***	0.281***
	(0.028)	(0.016)	(0.026)	(0.039)	(0.068)
Long-term (5-10 km)	0.107***	-0.081***	0.086***	0.280***	0.289***
	(0.022)	(0.013)	(0.022)	(0.036)	(0.063)
Long-term (10-15 km)	0.008	-0.038***	0.044**	0.138***	0.202***
	(0.023)	(0.012)	(0.021)	(0.032)	(0.056)
Long-term (15-20 km)	-0.001	-0.015	0.011	0.069**	0.112*
	(0.024)	(0.012)	(0.022)	(0.034)	(0.059)
# Observations			37043		
# Municipalities			1259		

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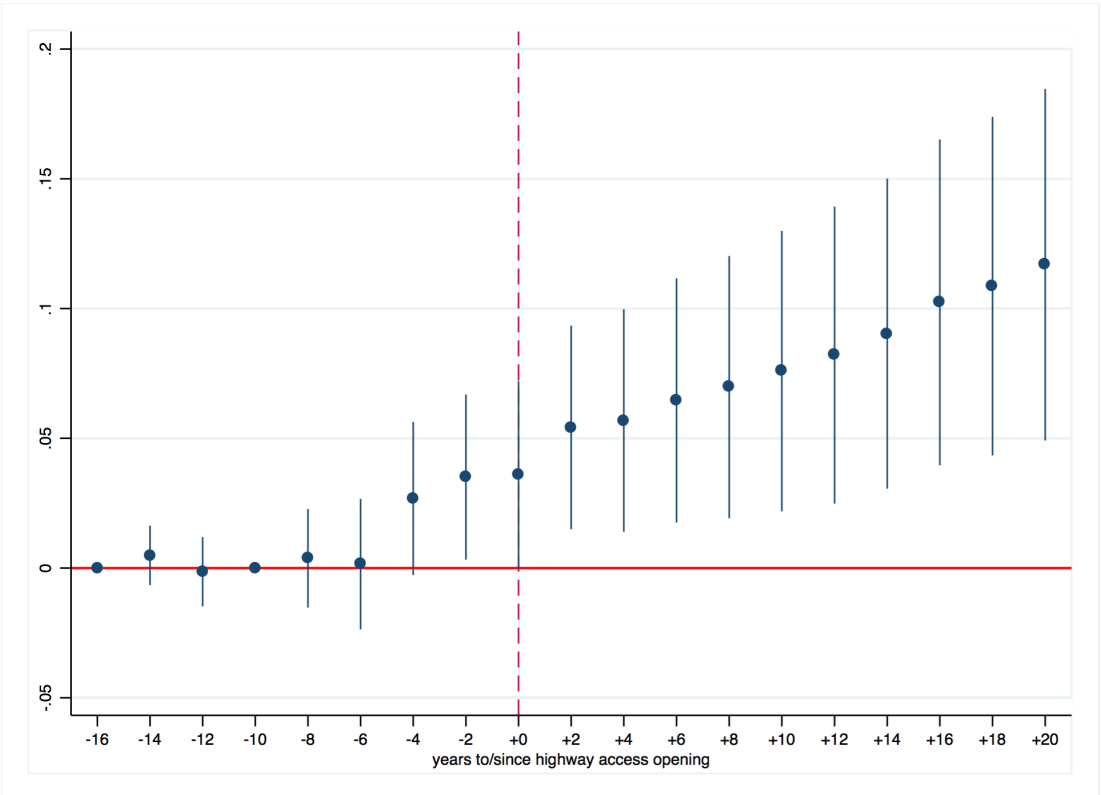
Appendix – Leads

Figure: Effect on number of taxpayers over time



Note: The figure shows the point estimates of dummy variables for 16 years before and up to 20 years after the opening of the highway access. The last dummy variables takes the value 1 after 20 years and during all years thereafter. The (balanced) sample includes all municipalities with a highway connection opened between 1969 and 1989. The regression includes municipality fixed effects, time fixed effects and municipality-specific linear time trends. Two-year panel covering the period 1949-2010.

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