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Price impacts of environmental services and the attractiveness of architectural form: Recent experiences

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May 2015

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Swiss Federal Institute of Technology Zurich

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Starting point: (reduced form) hedonic model

Basic idea is, that

the observable price of a good

reflects the

market equilibrium

and is a function of its

measurable attributes

And the obvious problems

Which price has been observed?

- asking price
- paid price
- effective price, accounting for later discounts (loyalty cards), reimbursements, additional services, etc.

Is the market in equilibrium?

- For the buyer (e.g. discrimination, lack of information)
- For the seller (e.g. urgency of sale, regulatory constraints)

What is measurable?

- Style of building
- Match between needs and the ability of the good to meet them

Points of use

- Construction of price indices
- Non-equilibrium models of markets:
  - Housing
  - Offices
  - Car
- Cost-benefit analysis
  - Externalities
  - Wider economic benefits

Modelling approach

- Regression models
- Spatial regression models
  - Spatial lag
  - Spatial error
  - Durbin: Combined spatial lag and error
- Additive and multiplicative formulations
- Object or per unit – prices

Modelling approaches

OLS model:

$$P = \beta X + \varepsilon$$

$$\varepsilon \sim N(0, \sigma^2 I_n)$$

Spatial error model (SARerr)[1]:

$$P = \beta X + u$$

$$u = \lambda W u + \varepsilon$$

Spatial Durbin model (SARdurbin)[1]:

$$P = \rho W P + \beta X + W X \gamma + \varepsilon$$

Lehner, 2011

Singapore's housing market

HDB sector (~ 80% of flat stock)

Low prices

New sale
- Highly regulated and subsidized
- Citizens / PR only

Resale
- Moderate regulations
- Citizens / PR only

Rental
- Social housing
- Temporary housing

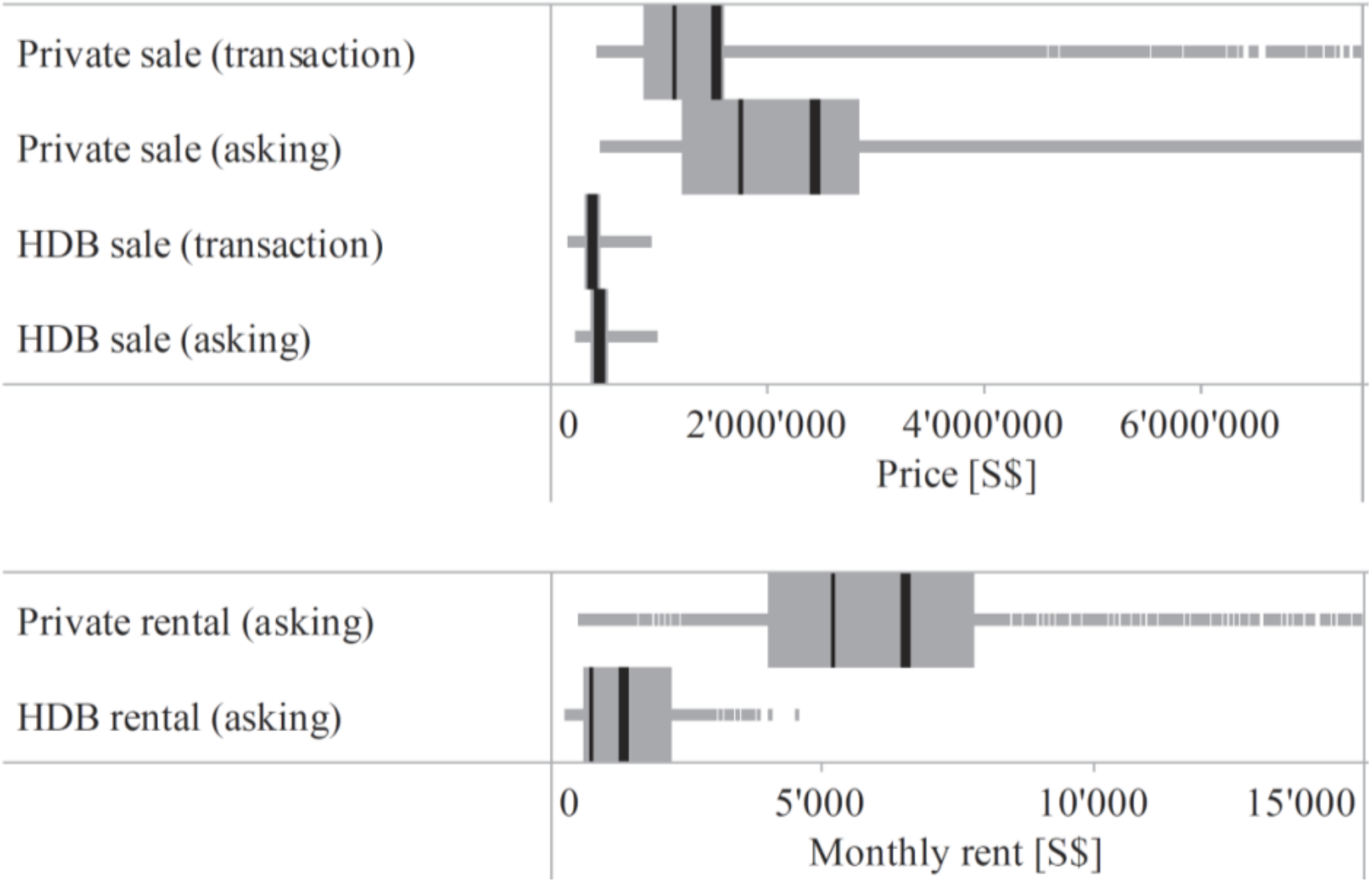
Private sector (~ 20% of flat stock)

High prices

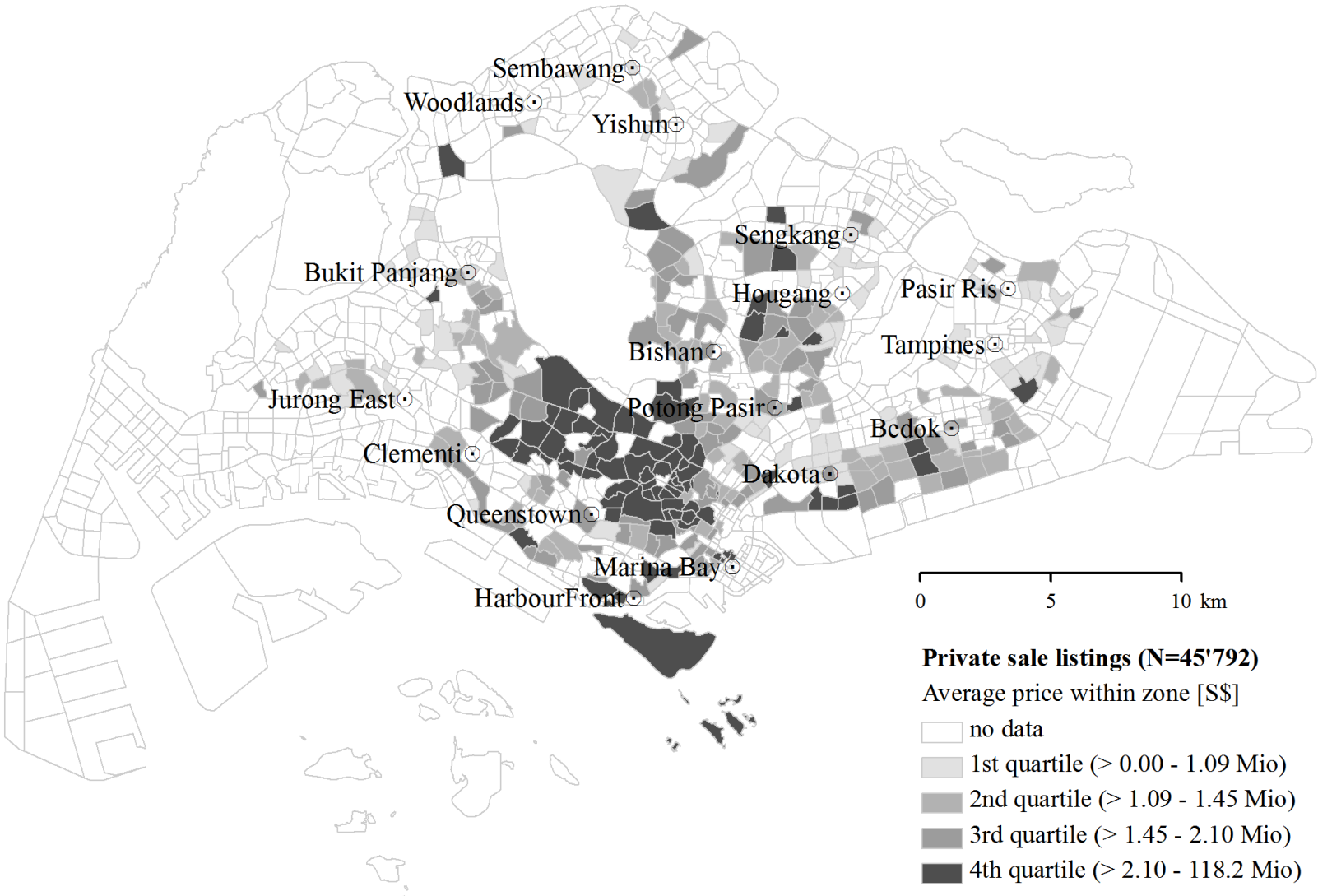
Sale
- Deregulated
- High-income Citizens, Expats

Rental
- Deregulated
- Mainly Expats

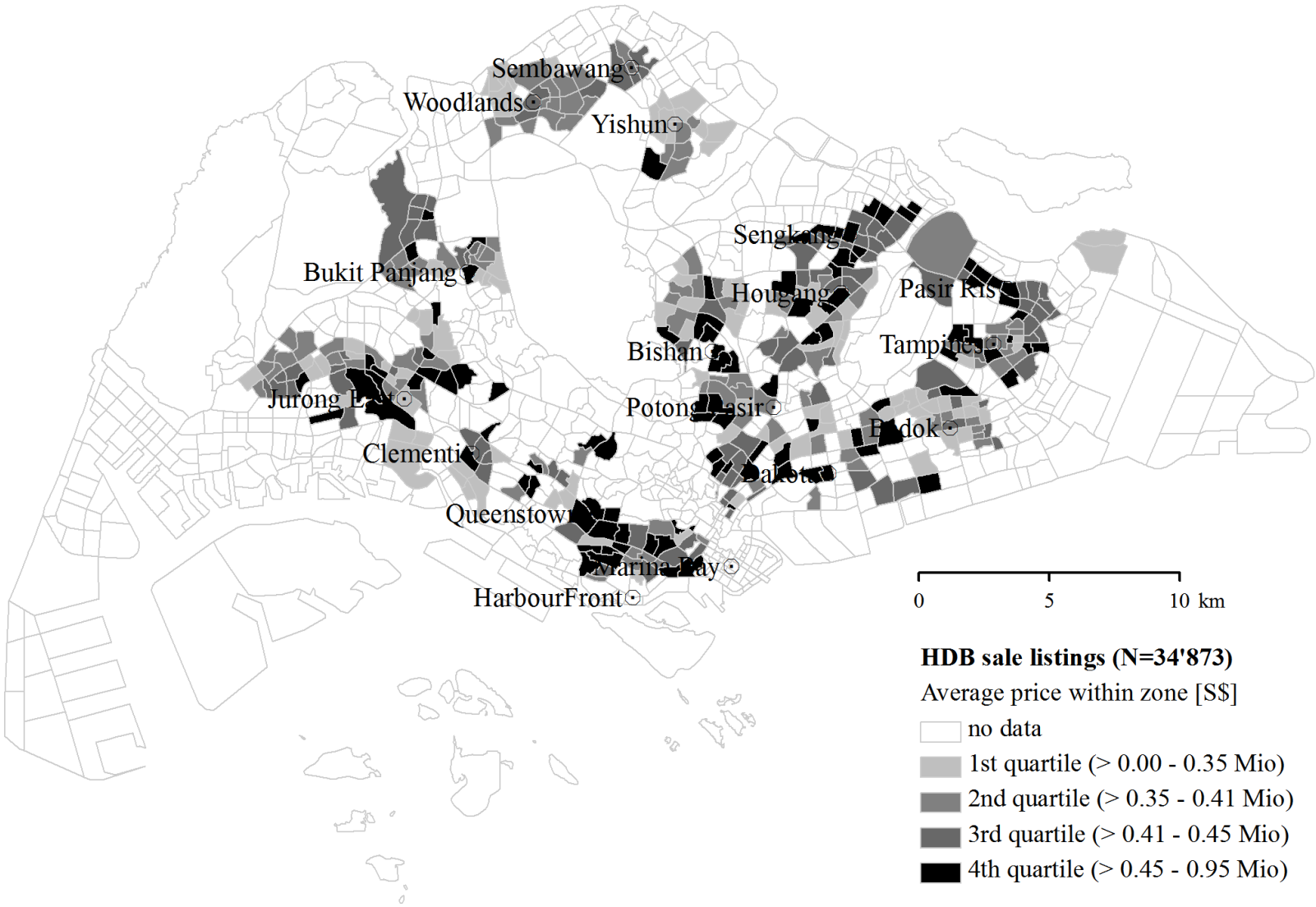
Comparison of markets: Price



Spatial pattern of housing prices: Private sale



Spatial pattern of housing prices: HDB sale



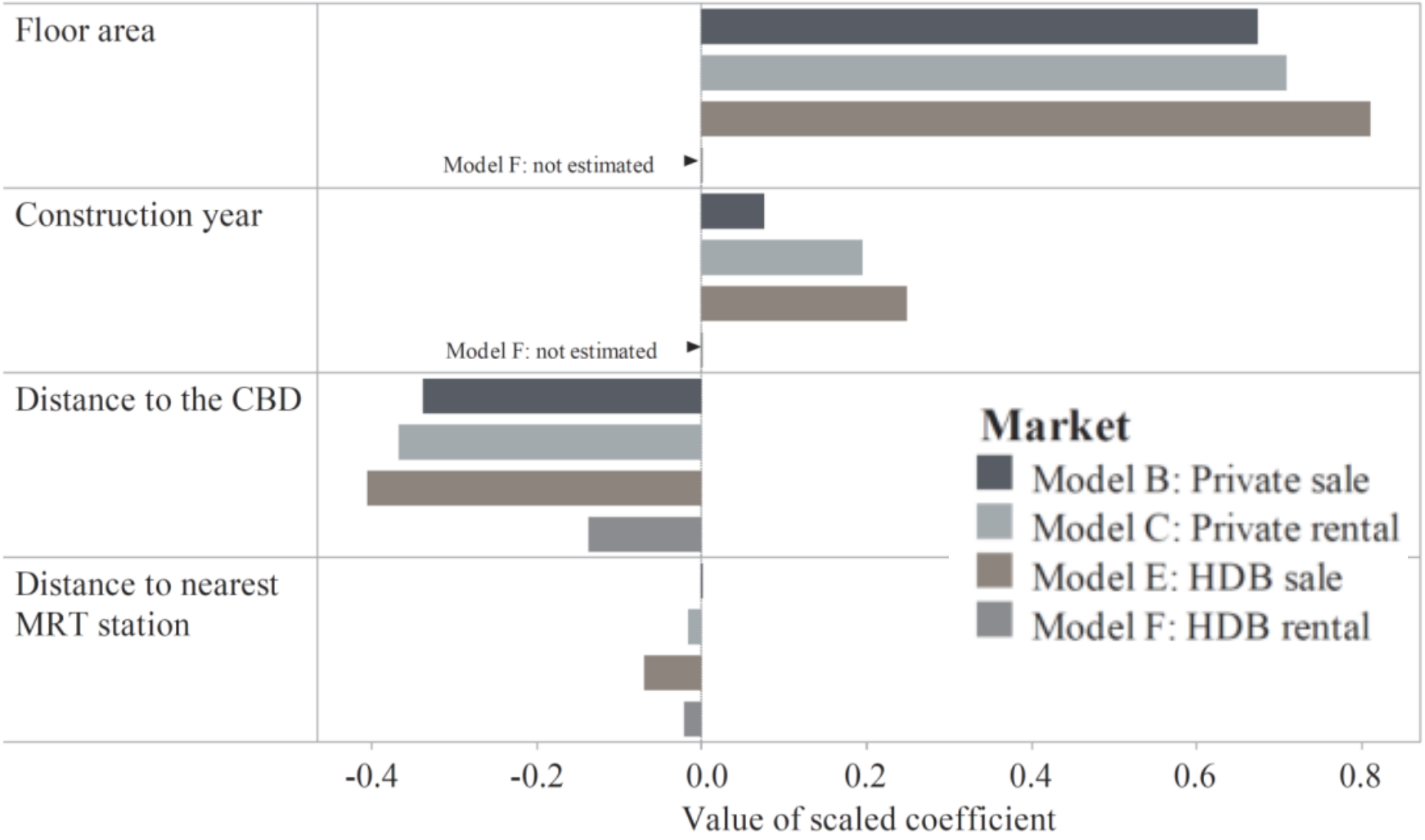
Overview of final models

Name	Market	Data	N=	Nvar=
Model A	Private sale	Asking and transaction	45'792	23
Model B	Private sale	Transaction	12'467	21
Model C	Private rental	Asking	22'444	19
Model D	HDB sale	Asking and transaction	34'873	13
Model E	HDB sale	Transactions	32'235	21
Model F	HDB rental	Asking	6'351	8

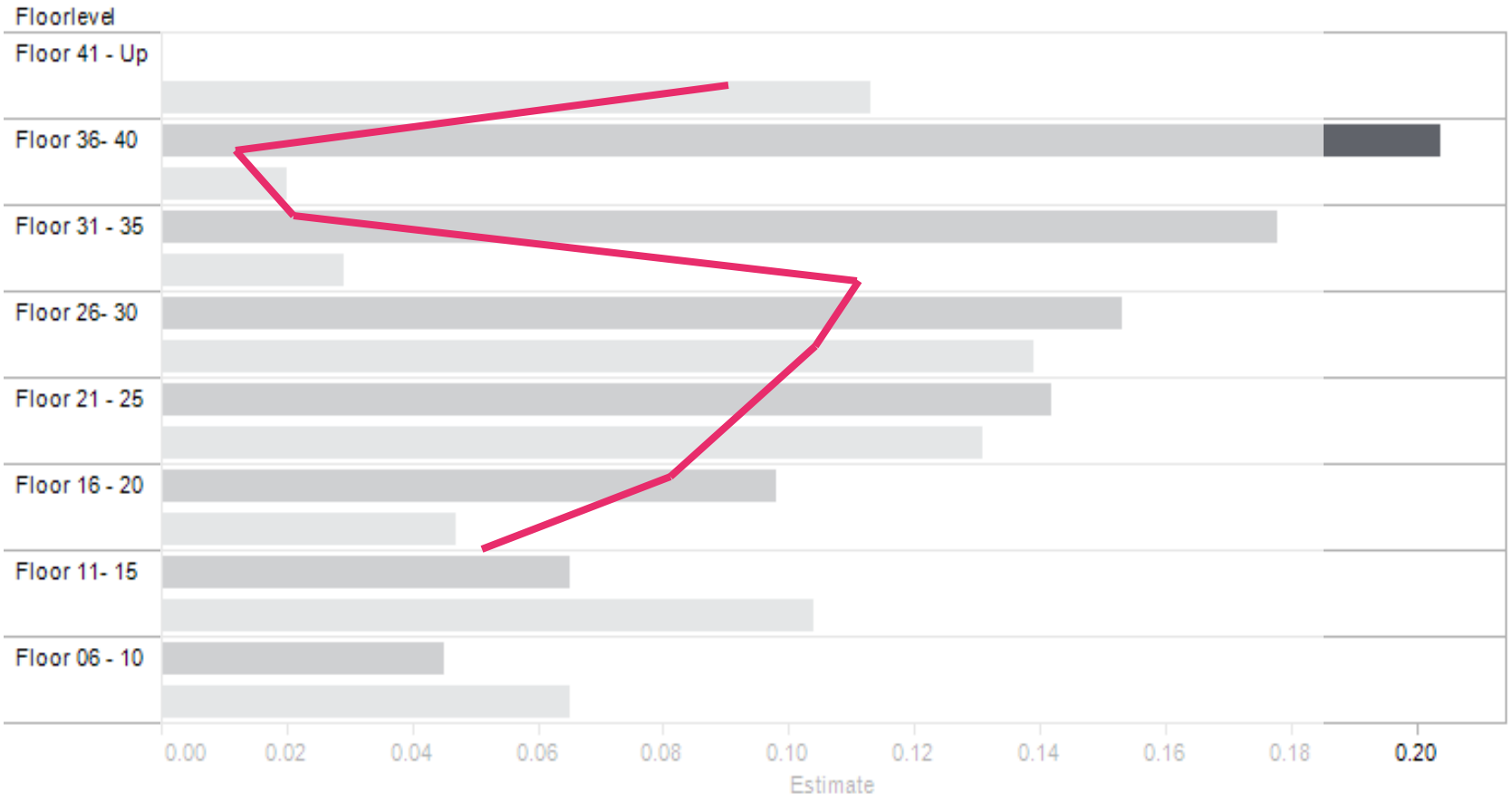
Model A: Estimated coefficients (selection)

Dependent: log(Price)	OLS model		Spatial error model	
N=45'792	Estimate	Scaled	Estimate	Scaled
Constant	11.098		11.822	
Lambda			0.920	
log(Floor area)	0.970	0.712	0.894	0.657
Built between 1951 and 1960	-0.213		-0.233	
Built between 2001 and 2010	-0.059		-0.035	
Planned to be built after 2011	-0.014		0.028	
log(Dist. to the CBD)	-0.316	-0.414	-0.334	-0.438
log(Dist. to a industrial estate)	0.078	0.101	0.037	0.047
log (Dist. to a top primary)	-0.027	-0.033	-0.035	-0.043

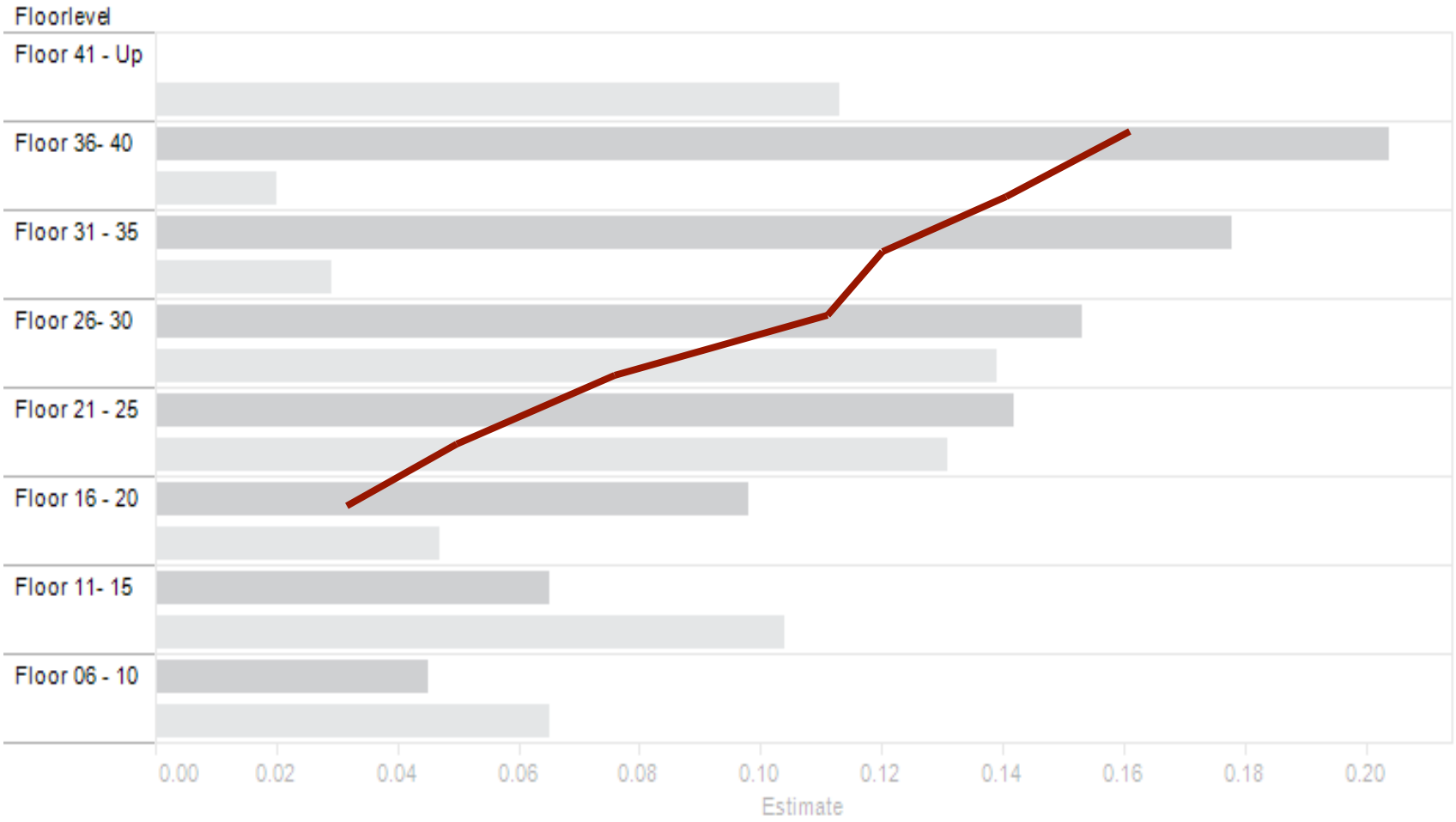
Comparison of housing preferences: Overview



Comparison of preferences: Floor level PRIVATE

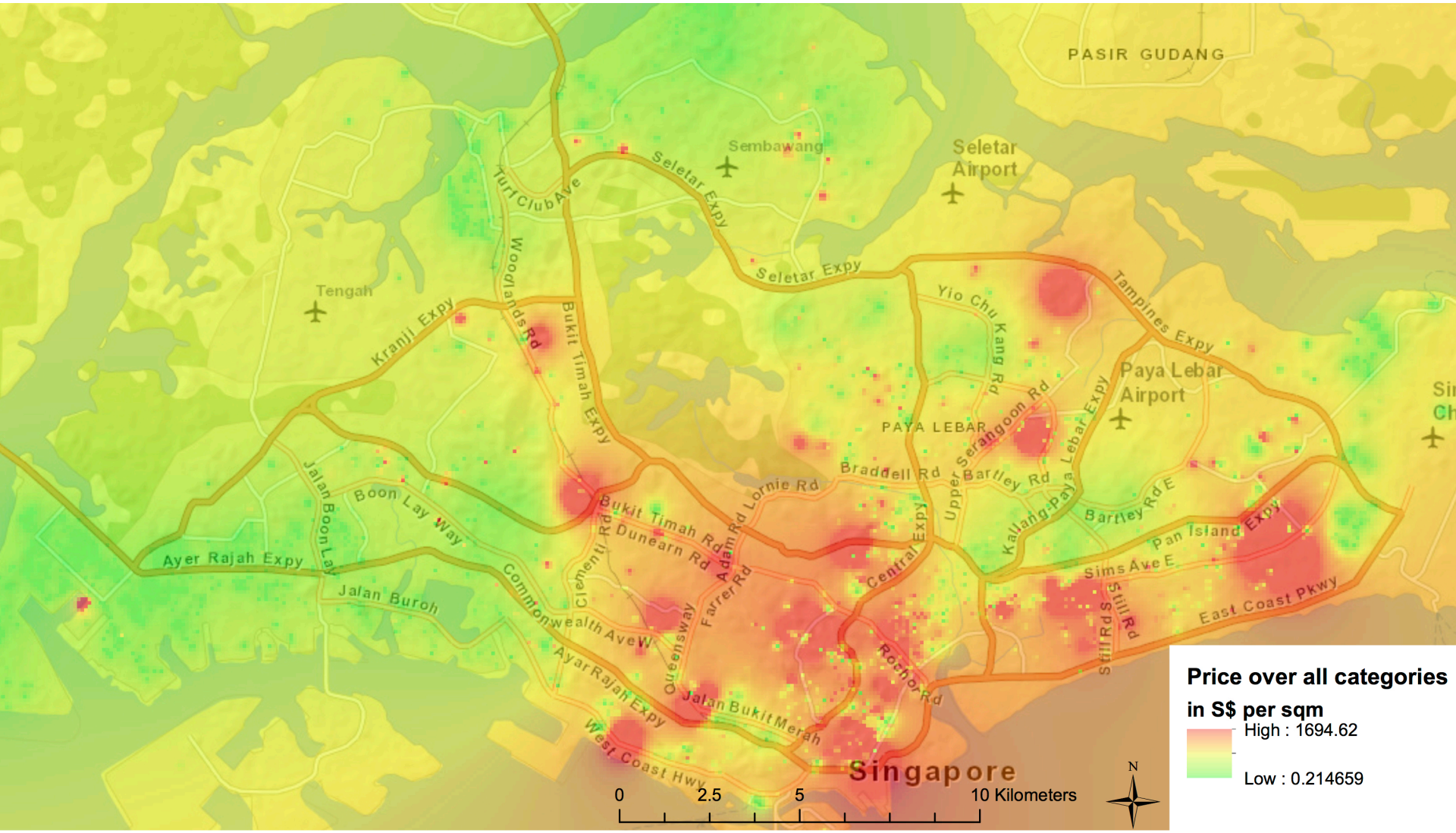


Comparison of housing preferences: Floor level HDB

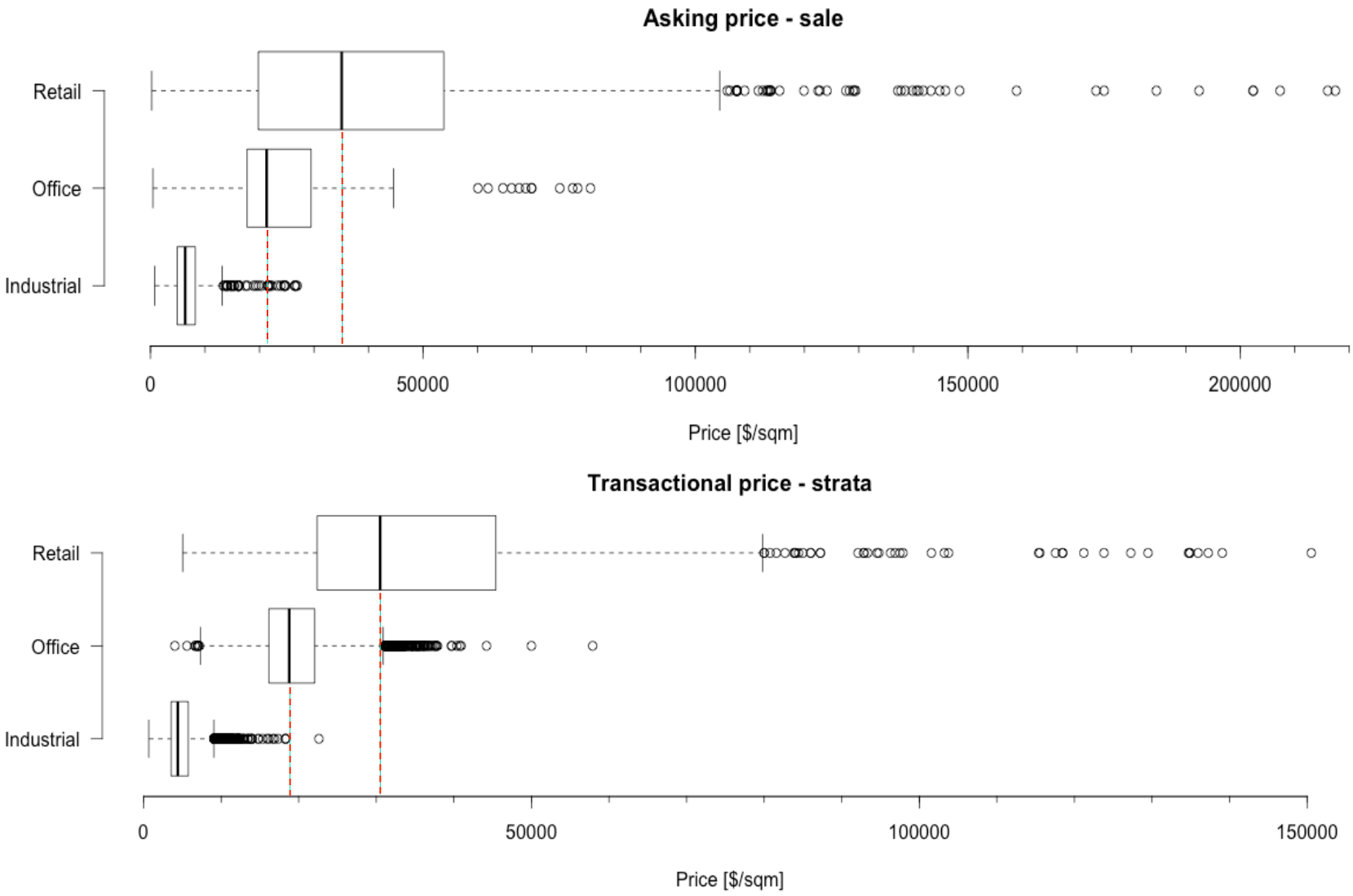


Caduff, 2013

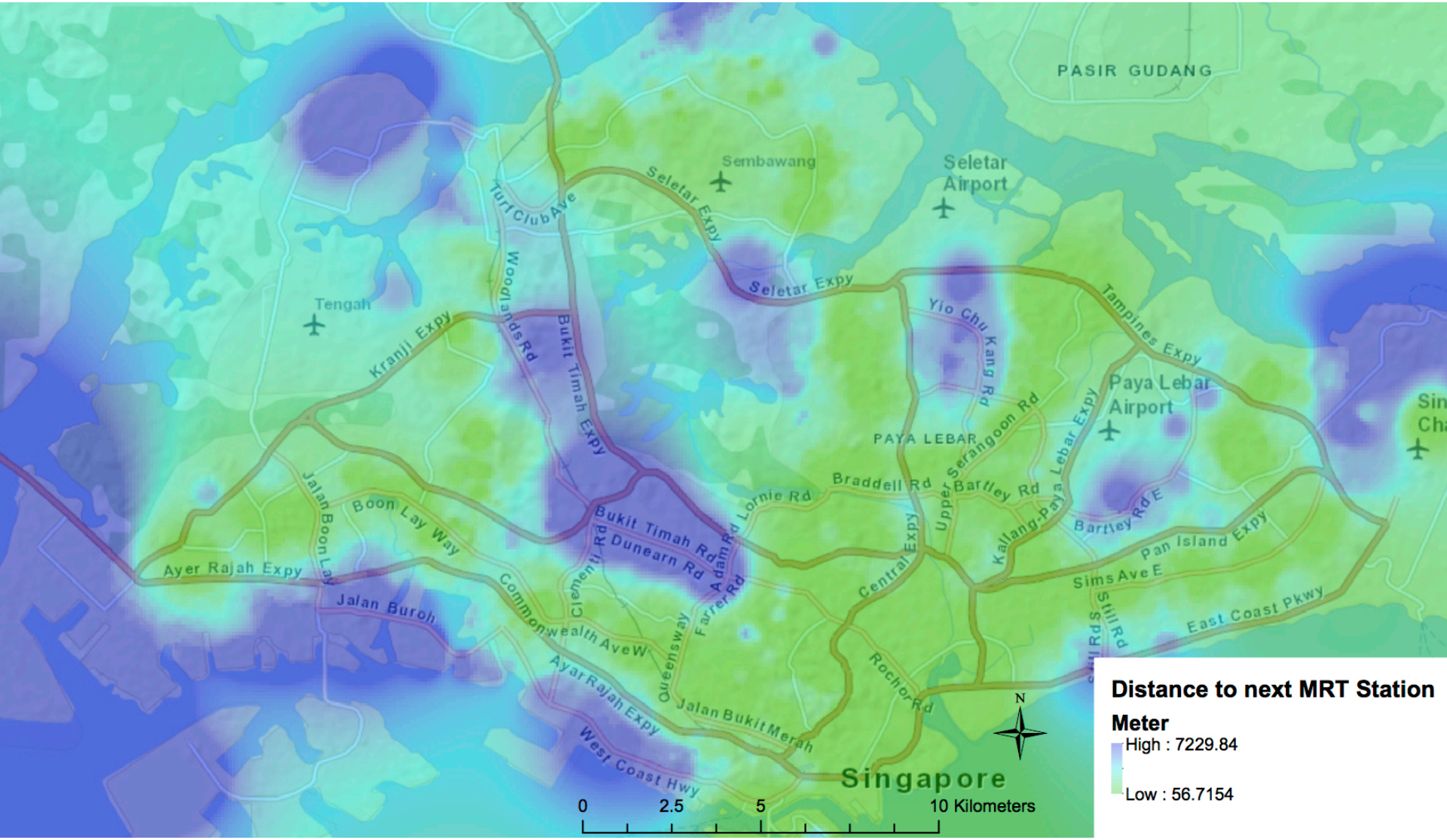
Price/m^2 for all markets



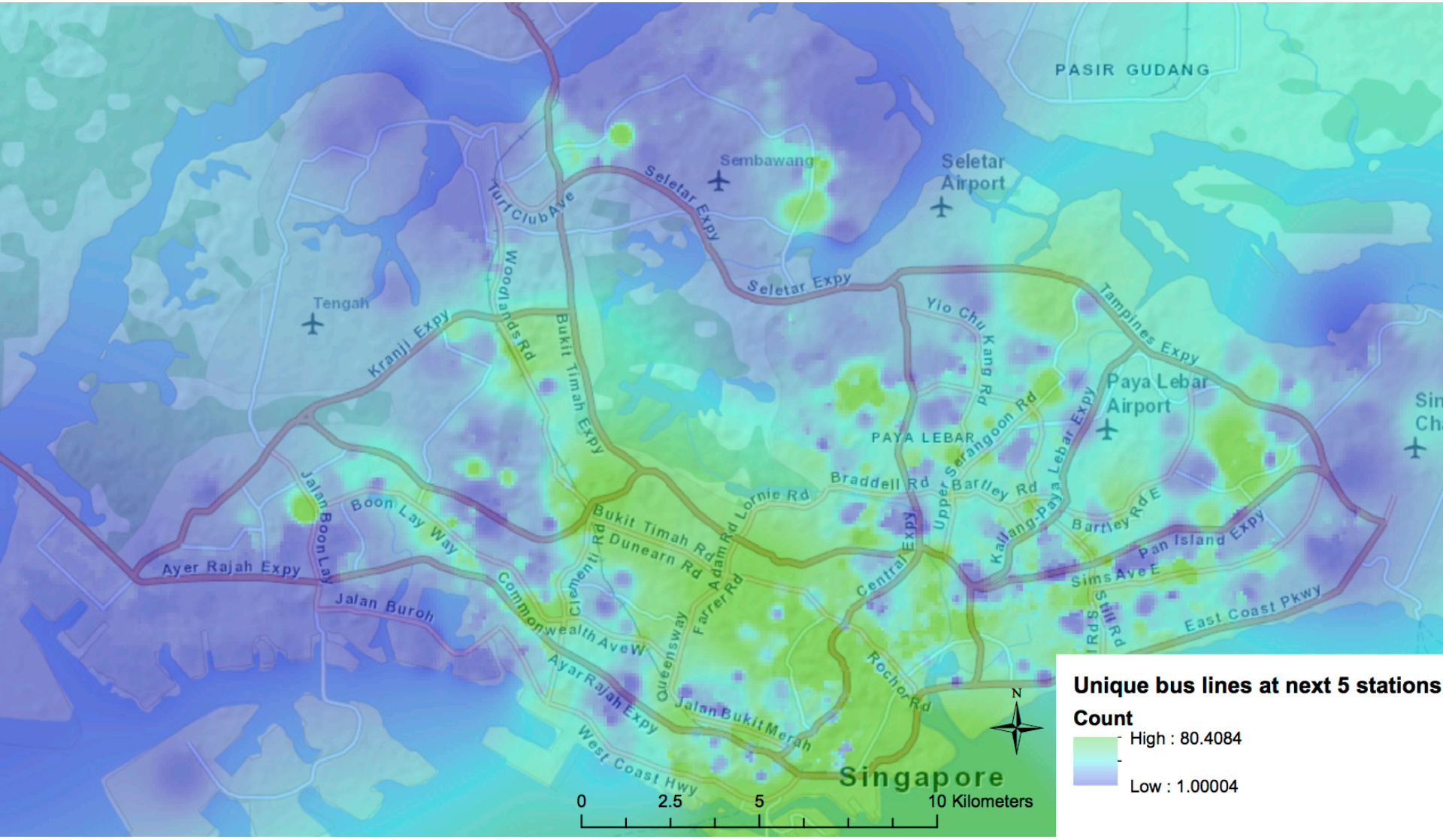
Price distribution



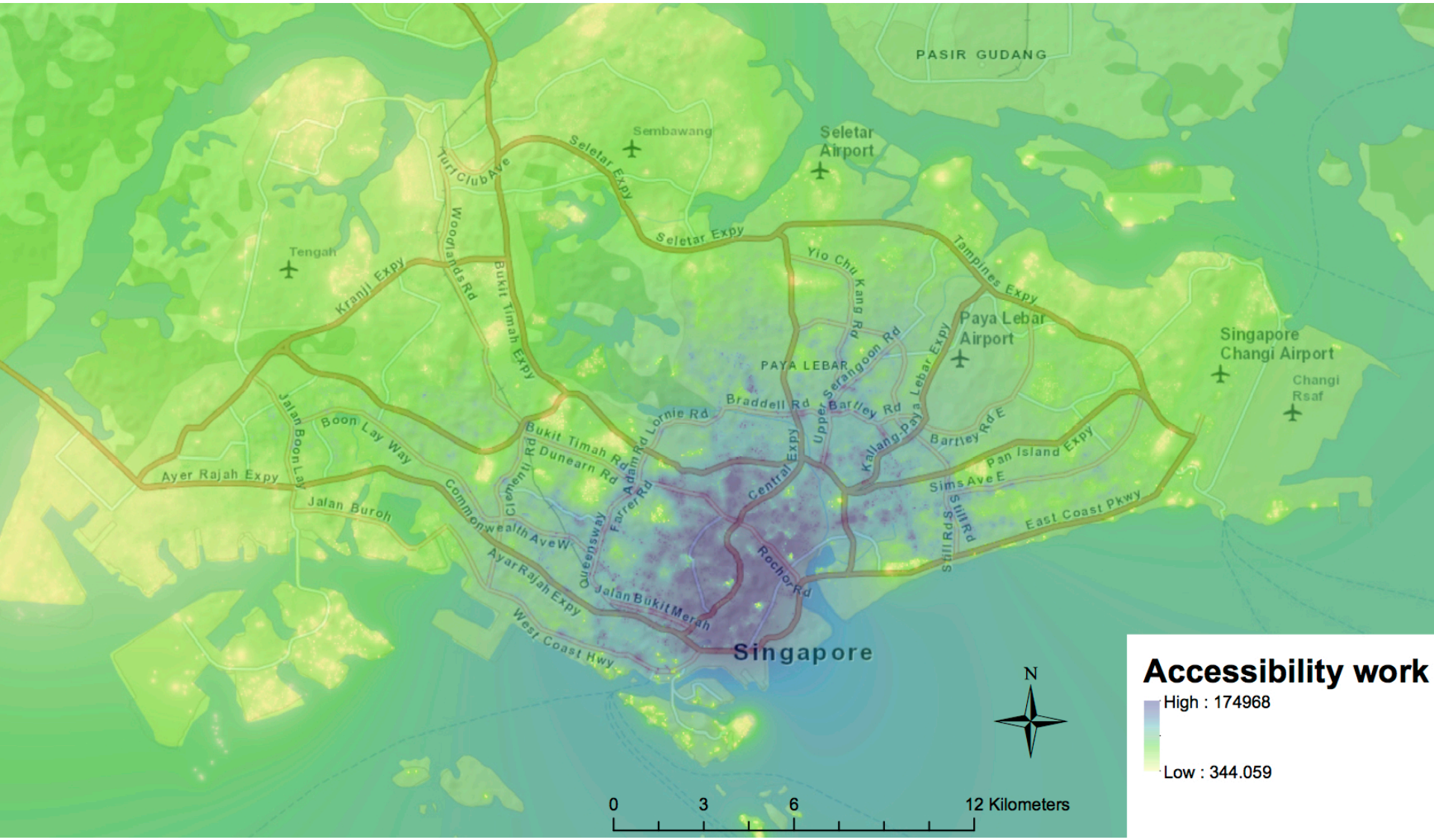
Access – Distance to nearest MRT Station



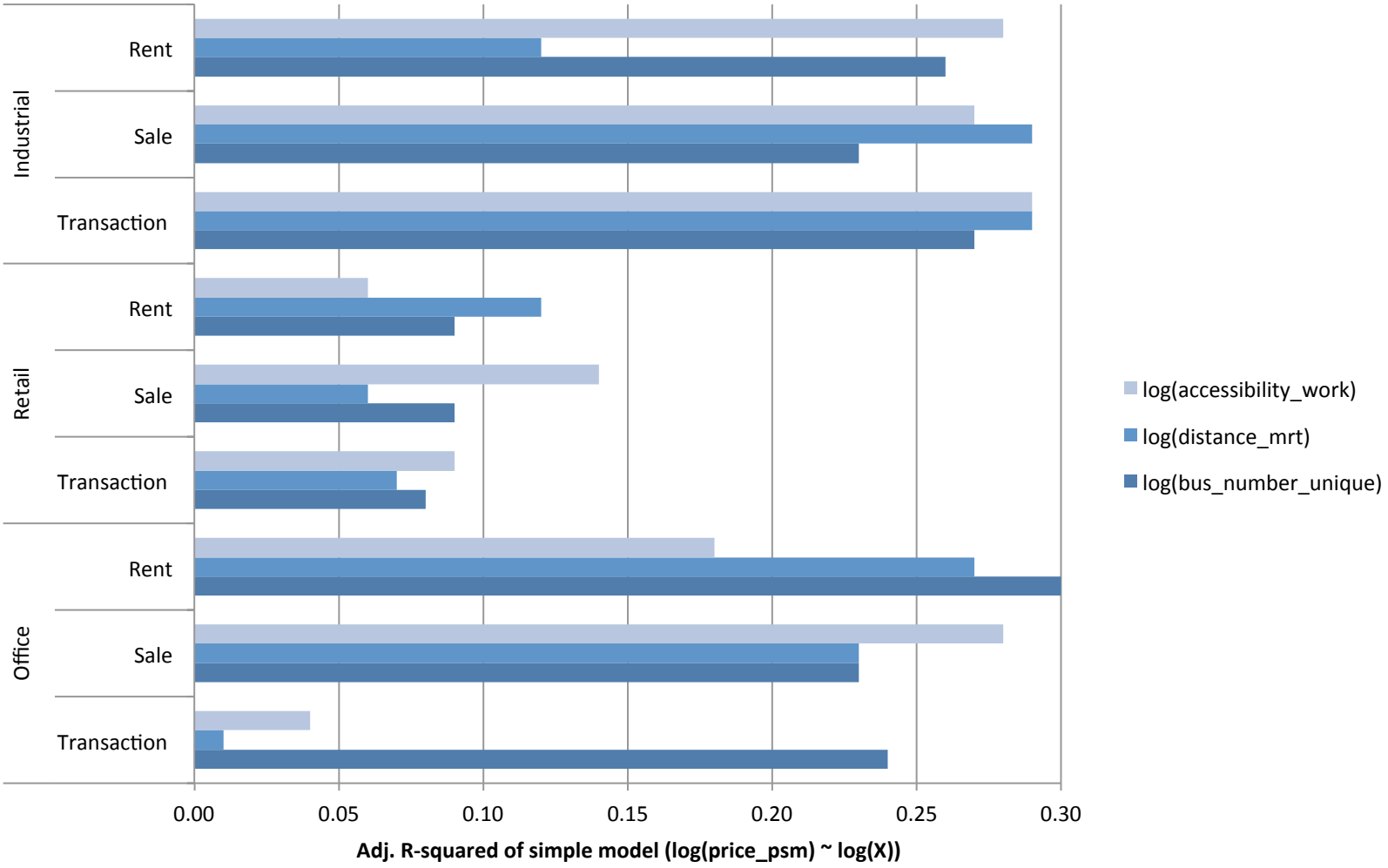
Access – Number of bus lines at next 5 bus stations



Accessibility work



Results - One-variable model - Access / Accessibility



Results – Price per m² – Offices – Spatial error

Variable	Transaction	Sig	Asking price	Sig
Constant	9.13	***	11.06	***
ln(Floor area)	-0.10	***	-0.11	***
ln(Distance to MRT)	0.12	**	-0.13	**
Number of unique bus routes	0.01	***	0.00	
Freehold	0.00		0.00	
30/60 year lease	--		-0.60	***
99 year lease	-0.19	***	-0.13	*
999 year lease	-0.09		0.29	***
Tenure not available	--		-0.07	
Katong area	0.25	*	-0.10	
Orchard area	0.27		0.10	
CBD area	0.37	***	0.51	***
Victoria Street area	0.10		0.35	***
Lamba	0.79	***	0.89	***

Schirmer, 2015

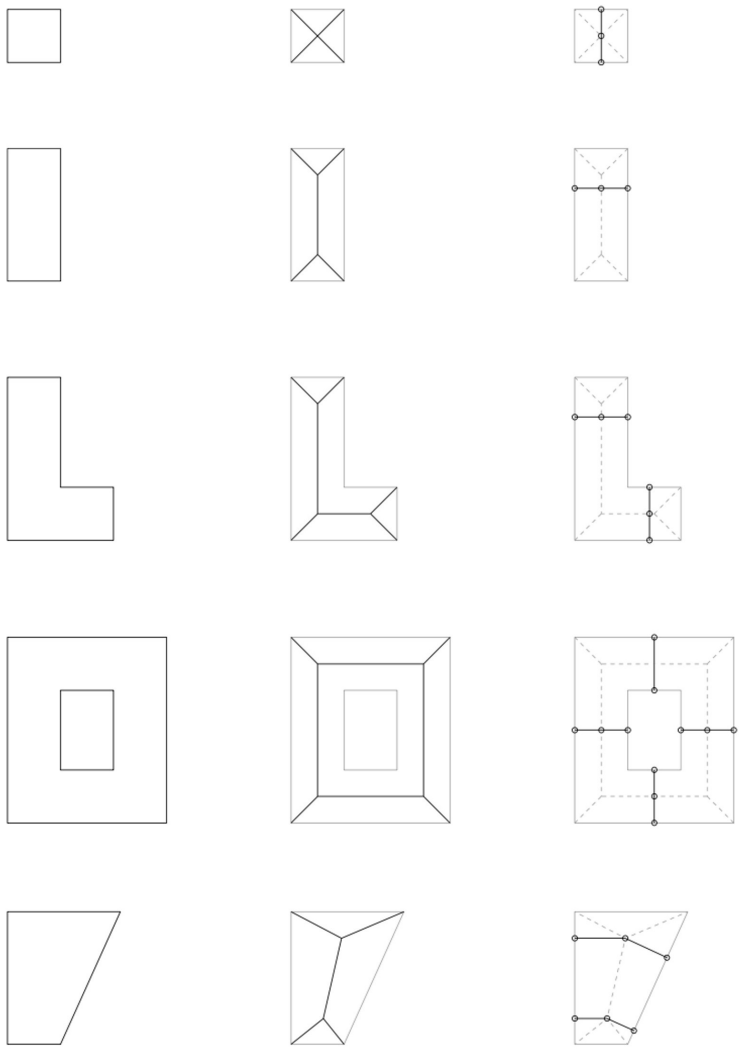
How to capture urban form ?

Houses and flats are more the properties of the flat:

- Form of the house (morphology)
- Urban form (morphology) of the group of houses
- Neighbourhood
- Municipality

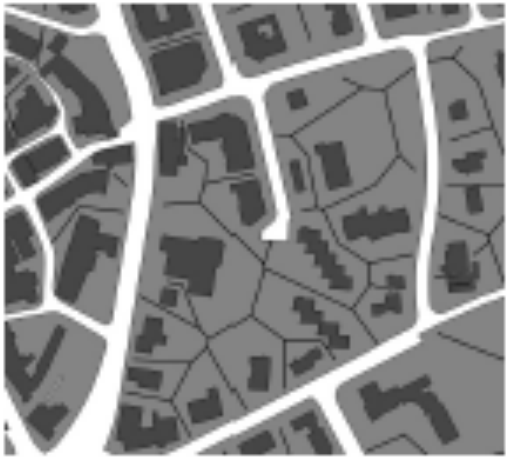
How to capture these automatically with GIS data ?

Object



Compactness
Skelet lines
Dead ends

Composition



Zone of influence
Permability
Degree of closure (Courtyards)

But what is the impact ?

Number	Variables	rho²
A1	Household, unit, accessibility	0.512
A2	1 + Socio economics of the area	0.513
A3	1 + Points of interest	0.522
A4	1 + Built environment	0.513

Number	Variables	rho²
B1	Base (summary of A1 to A4)	0.396
B2	Only object morphology	0.391
B3	Only composition morphology	0.392
B4	Only neighbourhood attributes	0.389
B5	Only municipal attributes	0.389
B6	Selected attributes across all	0.407

Example model of formulation B6 (MNL – DCM)

Variable	Beta	Sig.
ln(Distance to previous address) [km]	-2.03	*
ln(Distance to work place) [km]	-1.17	*
Road accessbility * Car ownership	-0.48	*
Public transport accessibility * No car	0.35	*
ln(building age)	0.27	*
New building	1.10	*
Rent to income ratio	-7.59	*
Room / Person	1.08	*
Room / Person (Singles)	-1.08	*
Floor area per room	0.02	*
Floor area per room (Singles)	-0.60	*
Volume to facade ratio	-0.26	*
Building foot print	0.14	*
Corner building	0.16	*
Permeability (views/area)	-24.00	*
Street orientation	-0.26	*
Distance to open landscape	0.97	*
Share of open landscape at neighourhood level	1.10	*
Share of urban tissue at neighbourhood level	0.35	*

Fuhrer, 2012

Ecosystem services

An ecosystem is defined by a certain combination of biotic and abiotic factors.

It provides wider services (externalities) to humans, e.g.

- Regulating evaporation
- Cooling the air
- Soil building
- Beauty

Ecosystem service variables

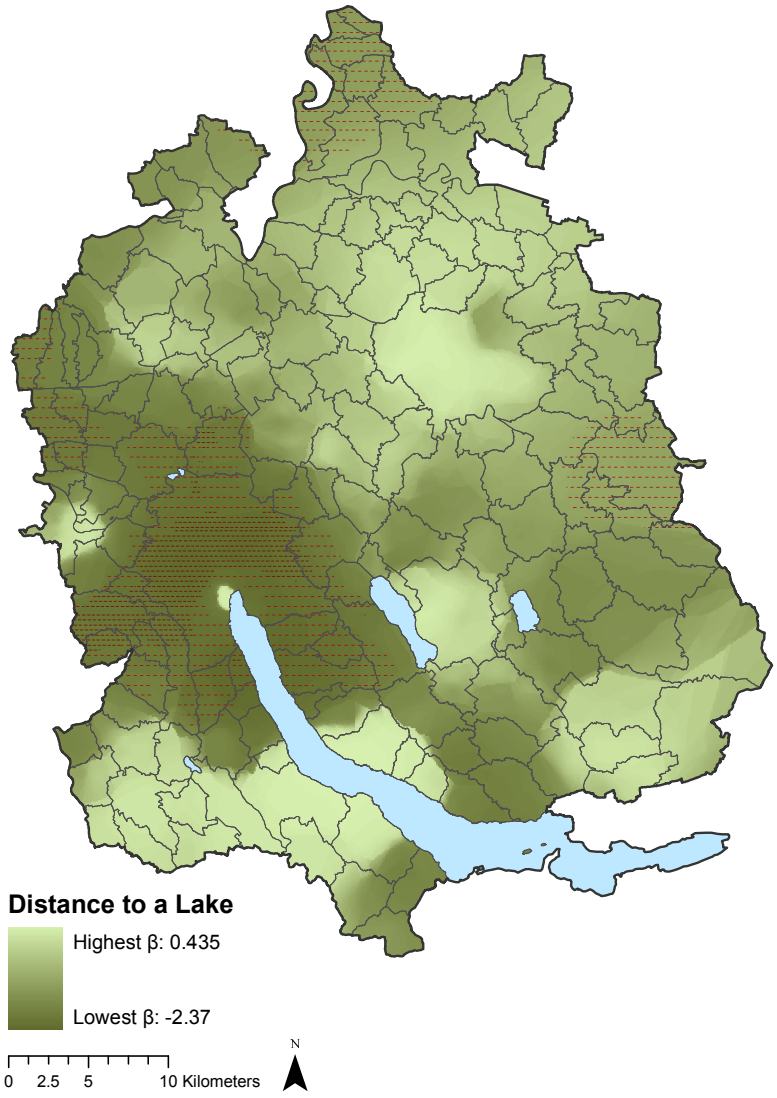
- Noise: Railway, street, aircraft, shooting ranges
- Air quality
- Forest: Distance and area
- Lakes: Distance
- Rivers: Distance
- Water: Area
- Agricultural areas: Distance and area
- Park: Distance and area
- Favourable areas: local and neighbourhood
- Visibility: Lakes and Mountains
- Indicator for ecology and identification

WTP results based on asking prices (N=3084)

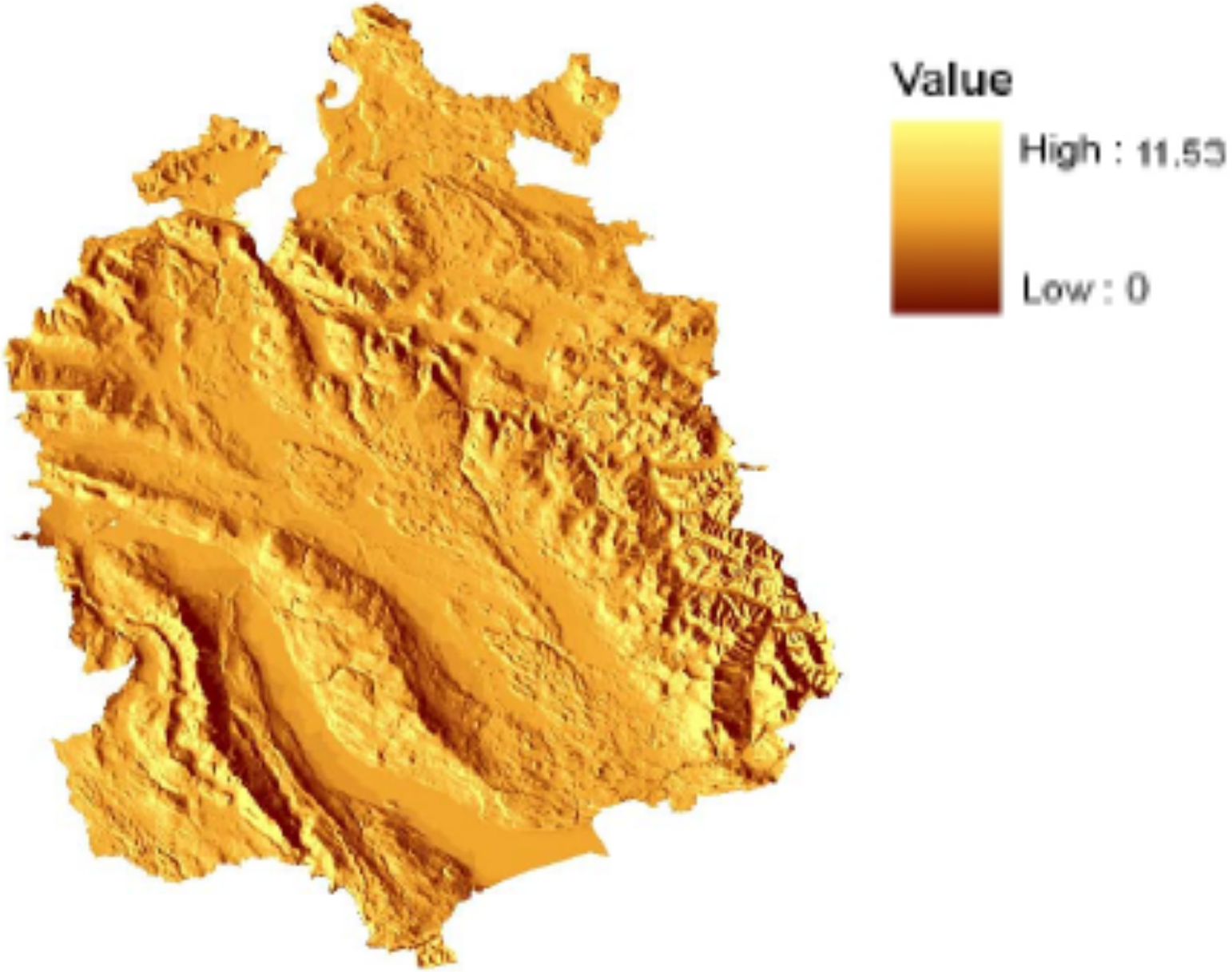
Variable	Unit	WTP [CHF]
Room	/room	184.00
Area	/m²	18.00
Before 1920		110.00
After 1991		185.00
Share of university graduates	%	56.00
Street noise	/dB(A)	-2.50
Railway noise	/dB(A)	-3.50
Distance to lake	/100m	-1.25
Distance to park	/100m	-10.00
View of lake	/100'000m²	7.15
View of mountain tops	/top	10.30
Population density	/%	2.45

Spatial heterogenity of impacts

Spatial heterogenity of impacts



Löchl – Evening sun along Lake Zürich



Kyoto May

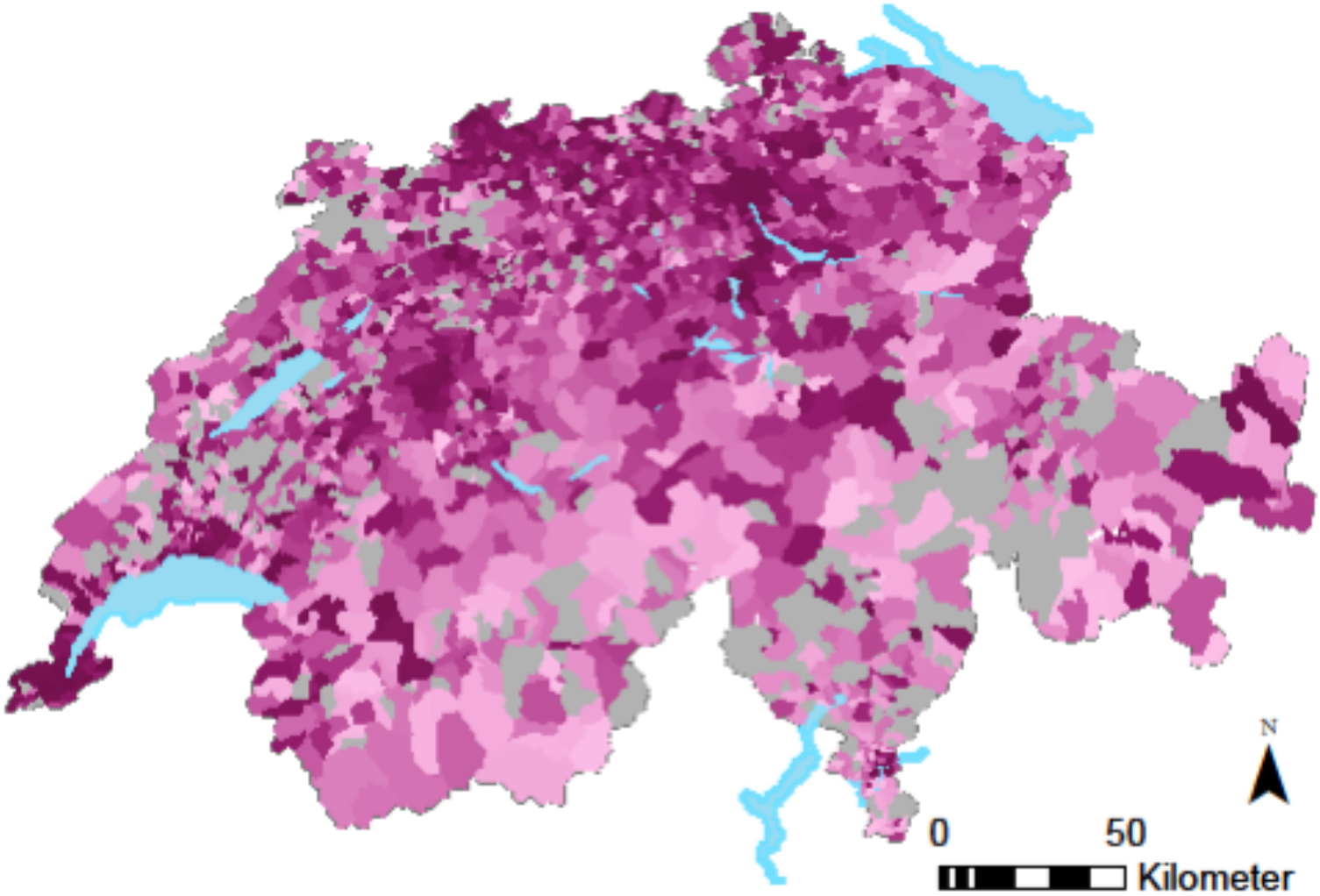
Source: Haase and Löchl, 2009

Sarlas & Fuhrer Swiss wages (2015)

Wider economic benefits: mean salary sensitive to

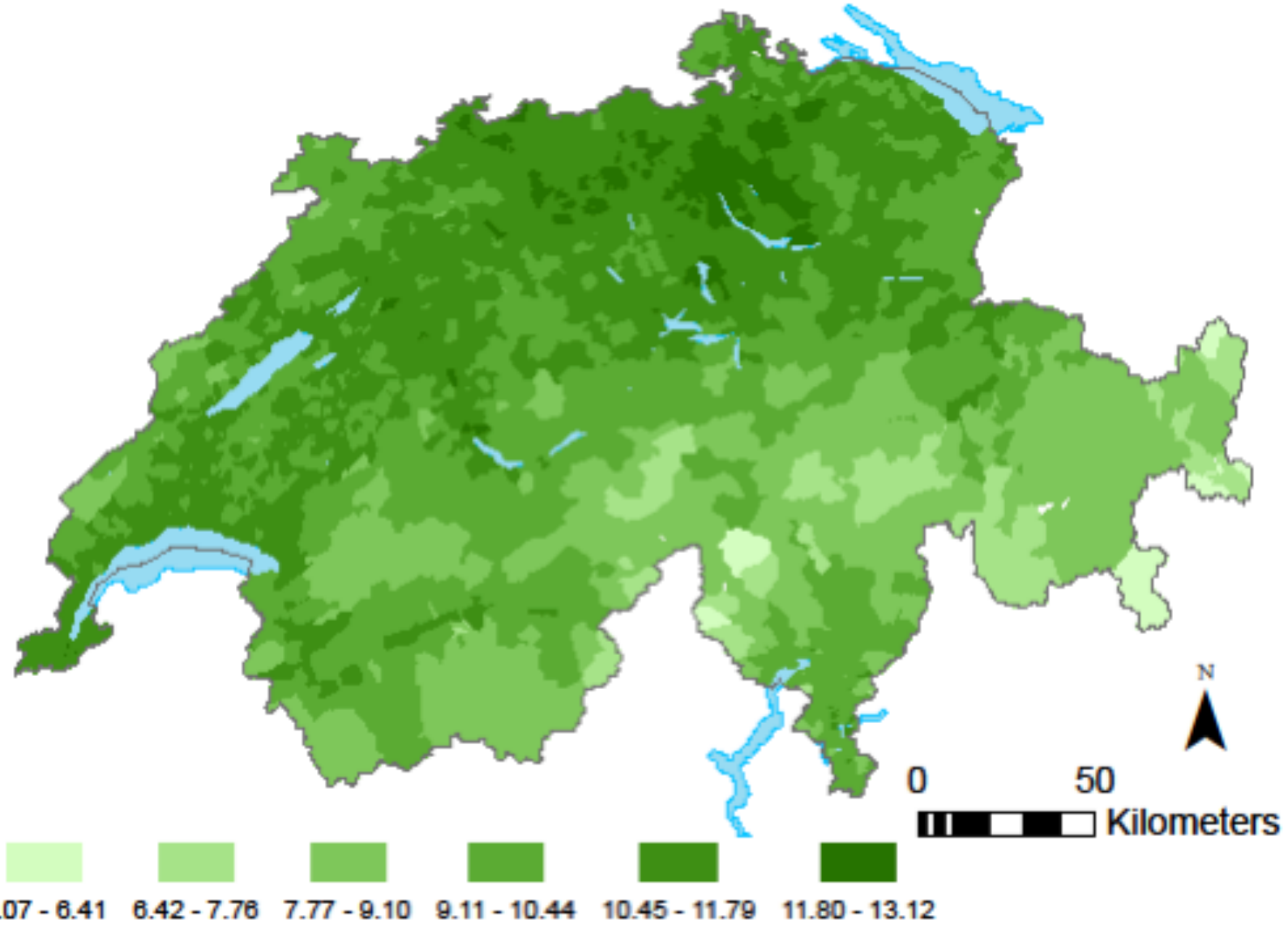
- Intensity of land use by
  - Population
- Network
  - Accessibility (road)
  - Accessibility (rail)
- Population composition
  - Gender
  - Education
  - Type of position
  - Time in post
  - In-commuters from abroad
- Industry
  - Share of industry

Mean salaries by municipality

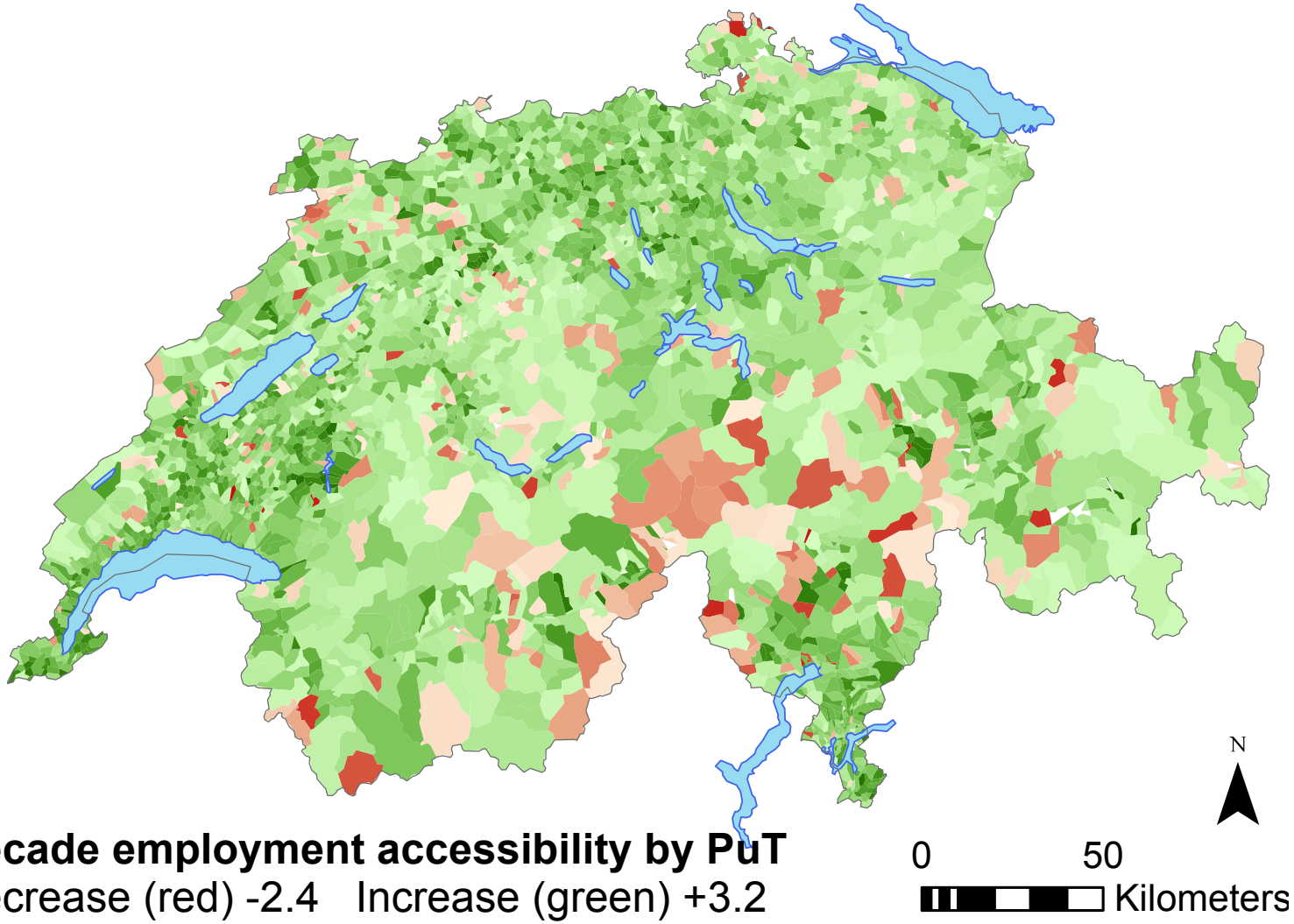


Grau: Weniger als 10 Observationen pro Verkehrszone
Hellste Farbe: Tiefster Lohndurchschnitt
Dunkelste Farbe: Höchster Lohndurchschnitt

Accessibility: Public transport 2010



Accessibility change: Public transport 2000-2010



ecade employment accessibility by PuT

ecrease (red) -2.4 Increase (green) +3.2

Analyses

- OLS (2000, 2005, 2010)
- Panel 2000-2010
- Pooled OLS (balanced, unbalanced)
- Spatial error model (SER)
- SER panel (2000-2010)
- GWR

Spatial panel 2000-2010

Variable	beta (All)		beta (Agglo)	
Intercept	6.26	***	6.18	***
Year 2005 dummy (time-effect)	0.08	***	0.08	***
Year 2010 dummy (time-effect)	0.12	***	0.11	***
Ln car accessibility	**0.01**	***	**0.03**	***
Ln public transport accessibility	**0.02**	***	**0.02**	***
Ln number of local employed	**0.02**	***	**0.01**	***
Commuter from outside Switzerland	-0.10	***	-0.12	***
Short residence permit	-0.15	***	0.06	
Average duration in-post	0.003	***	0.004	***
Ln average age	0.41	***	0.34	***
Men	0.14	***	0.09	***
N	930		763	
Rho	0.28	***	0.28	***

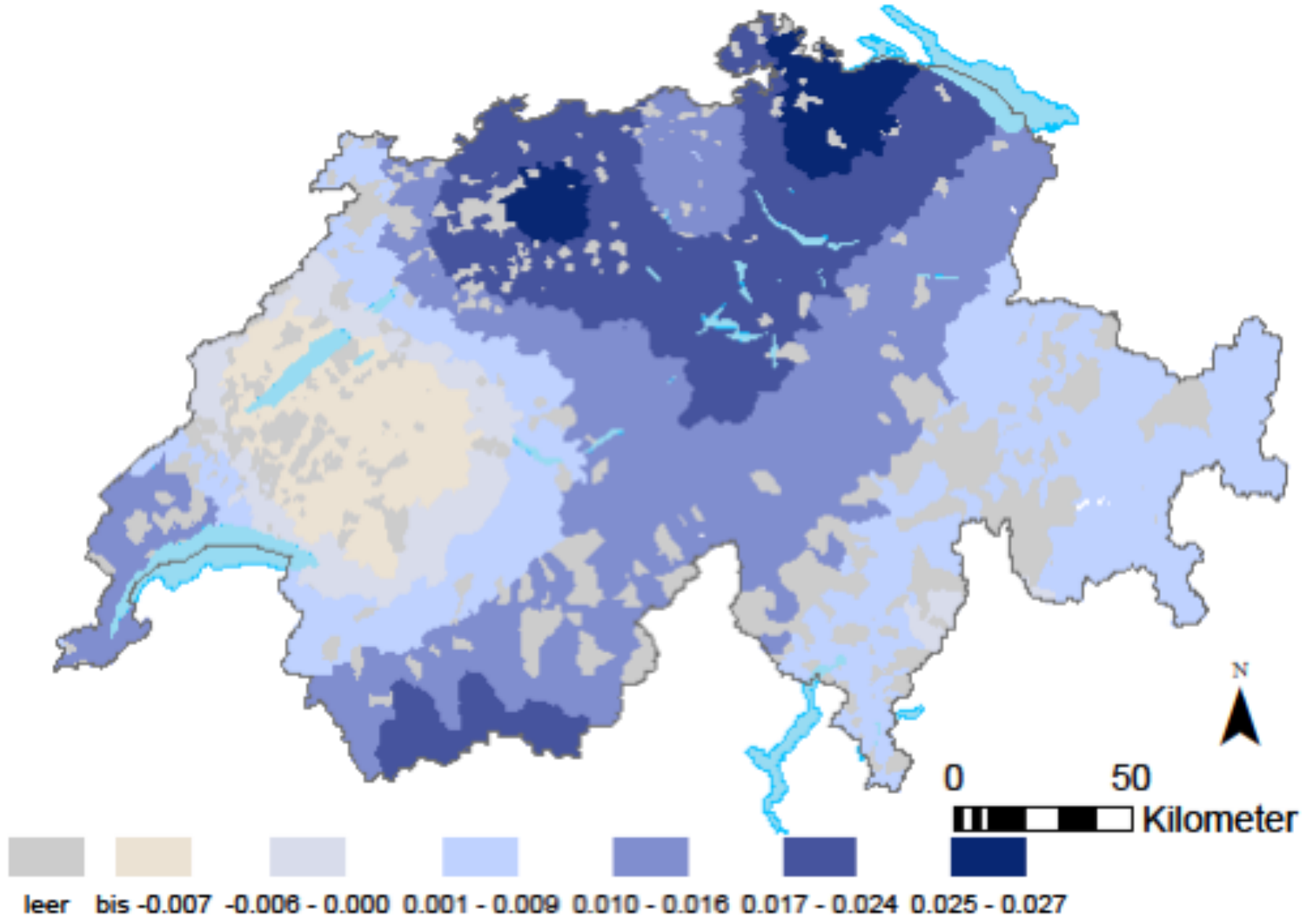
Spatial panel 2000-2010

Variable	beta (All)		beta (Agglo)	
Tertiary education	0.76	***	0.70	***
Professional training	0.37	***	0.33	***
Further vocational training	0.23	***	0.19	***
Teaching degree	0.35	***	0.43	***
Highschool diploma	0.34	***	0.43	***
Vocational training	0.07	***	0.09	***
Positions with highest demands	0.45	***	0.55	***
Positions with qualified indep. work	0.24	***	0.30	***
Positions with professional skills	0.17	***	0.16	***
Working (3rd sector)	0.18	***	0.26	***
Working (private sector)	-0.08	***	-0.03	**
Working (manufacturing)	-0.21	***	-0.21	***
Working (FIRE)	0.13	***	0.17	***
Working (hotel, restaurants)	-0.12	***	-0.160	***

Public transport accessibilities 2000-2010 elasticities

Model	2000	2005	2010
OLS	1.80%	1.60%	1.50%
Spatial error	1.60%	1.30%	1.20%
Pooled OLS			1.20%
Pooled OLS for 2005-2010			0.70%
Time-effects			2.00%
Time-effects for 2005-2010			1.50%
SER pooled OLS			0.90%
SER pooled OLS for 2005-2010			0.20%
SER with time-effects			1.70%
SER with time-effects for 2005-2010			1.20%

GWR estimates: public transport accessibility 2010



What is next ?

What have we learned ?

- Hedonic real estate price models
  - Importance of tenure and contract details
  - Difficulty to measure final prices paid
  - Spatial correlations are everywhere !
  - Need to break the markets down by type of buyer/tenant
    - Access to subsidies
    - Mortgage restrictions
  - Find the locally valued amenities
  - Difficulty to capture accessibility:
    - Which aspect ?
    - For whom/which activity ?
- Wider economic benefits
  - They are there, but are small
  - and therefore difficult to measure

Questions ?

www.ivt.ethz.ch

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