Commuting, public transport investments and gentrification

Evidence from Copenhagen

Ismir Mulalic

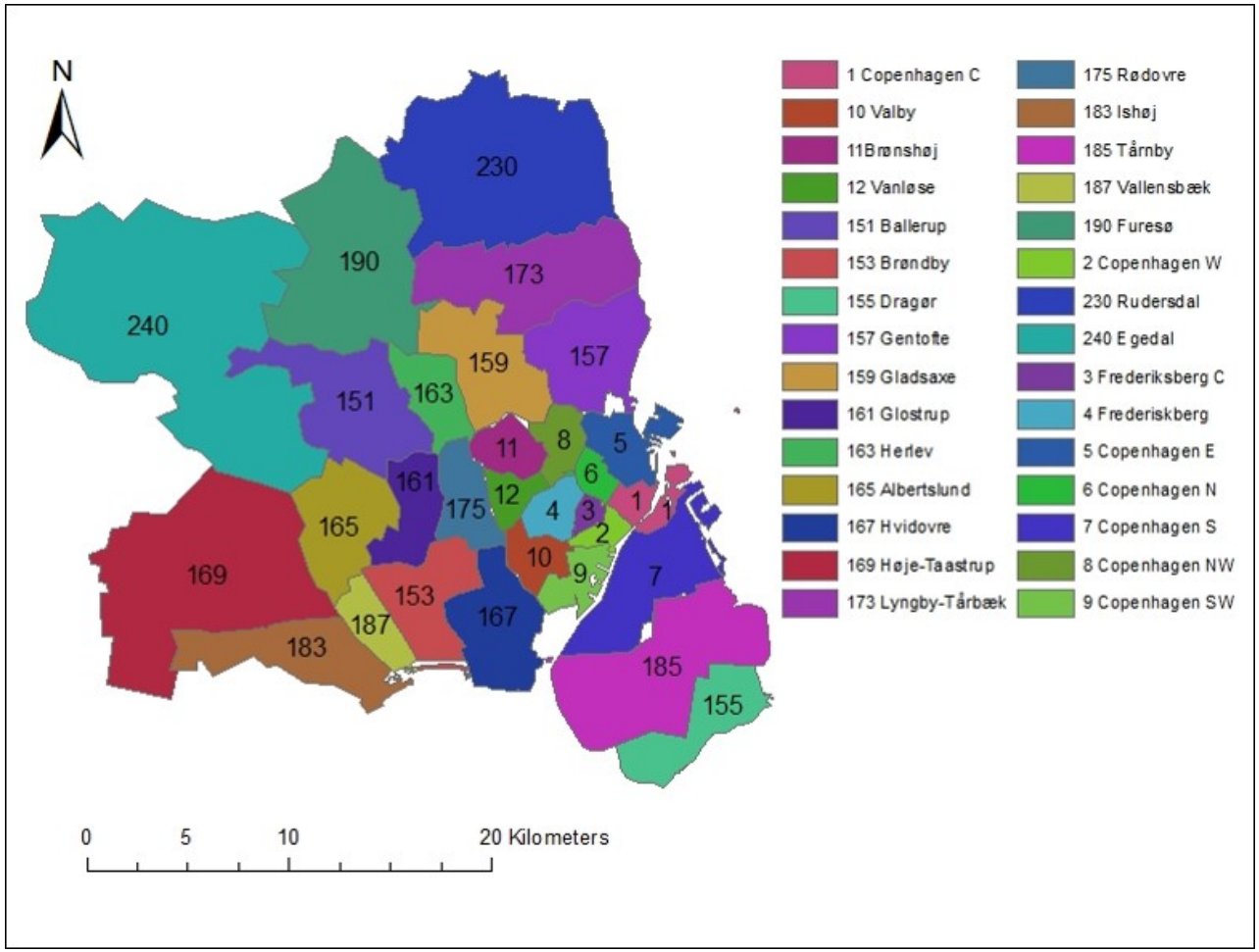
Technical University of Denmark and Kraks Fond

June 12, 2018

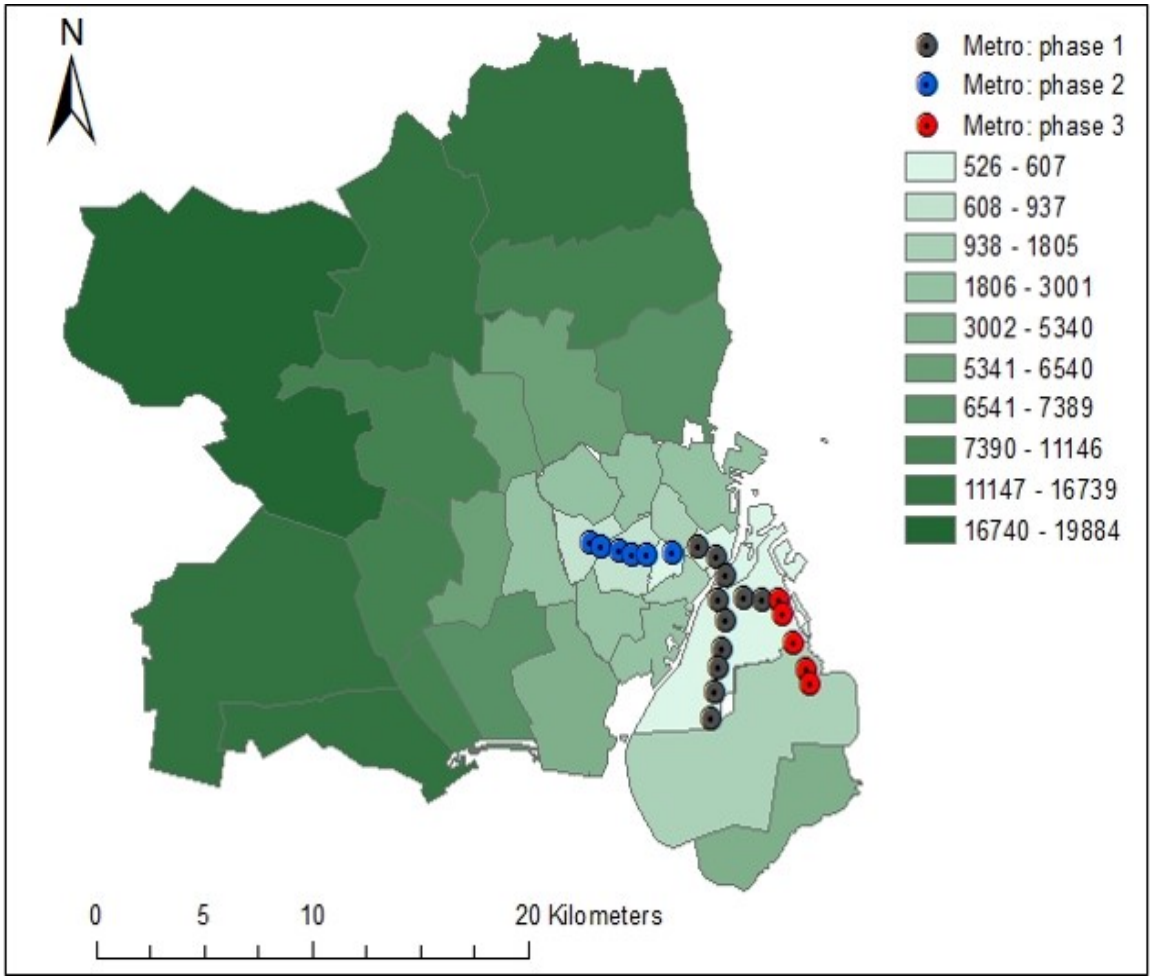
Public transport and cities

- Many European cities have ancient inner cities
- Street patterns and heritage make adjustments in traffic infrastructure very expensive
- **Underground public transport is attractive for inner cities**
  - contributes to triumph of European cities
  - stimulates gentrification
  - mitigates demand for cars
- Car infrastructure tends to make suburbs better accessible

Copenhagen Metropolitan Area



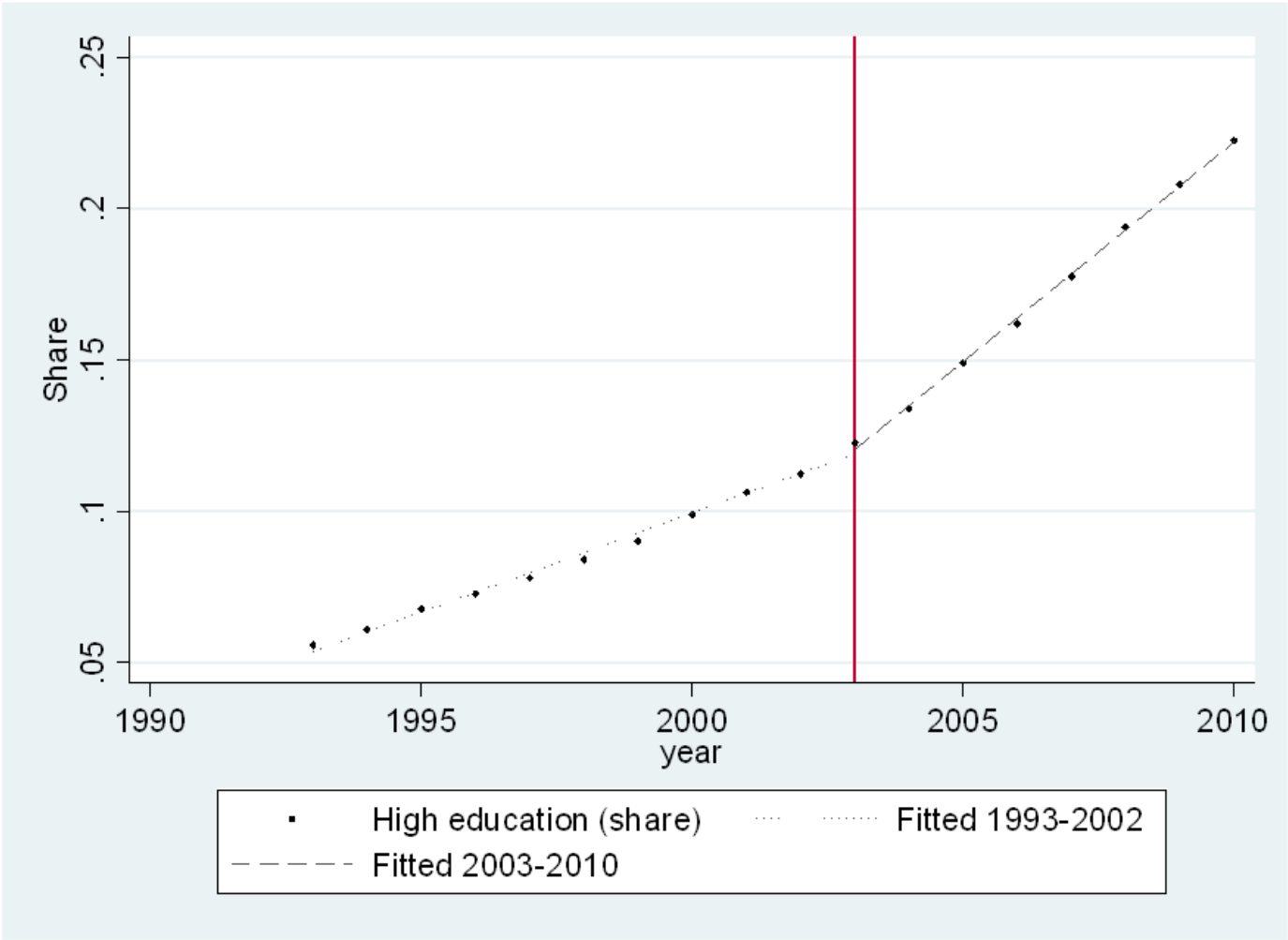
The metro network



Impact of metro on urban structure

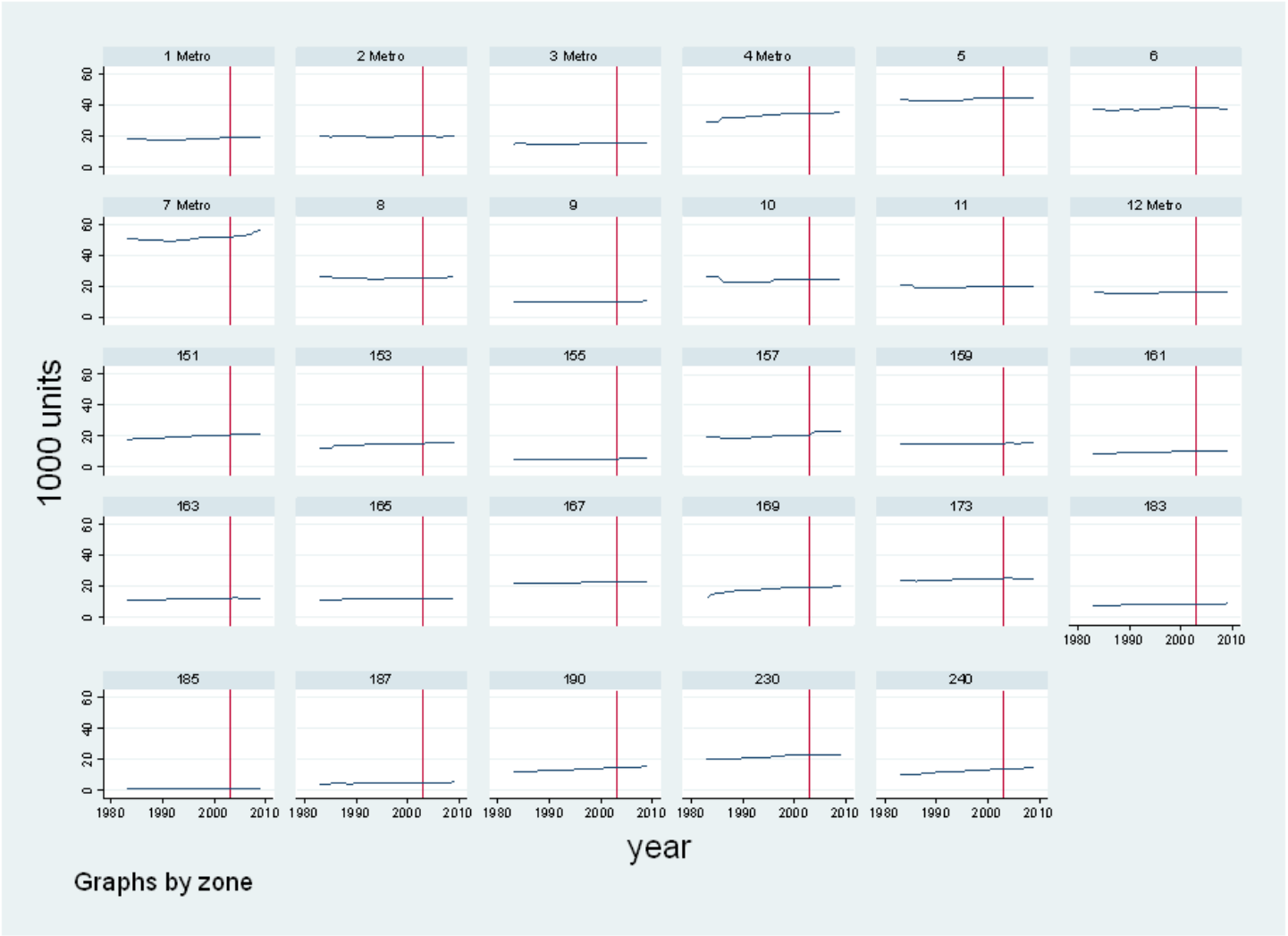
- Decrease in travel times (and increase in reliability and comfort) for trips that can make use of metro
- Makes it more attractive to live and work close to metro stations
  - pushes up demand for housing and supply of labor
  - effects may be heterogeneous $\Rightarrow$ possible relationship with **gentrification**

Share of higher educated in Copenhagen S (zone 7)

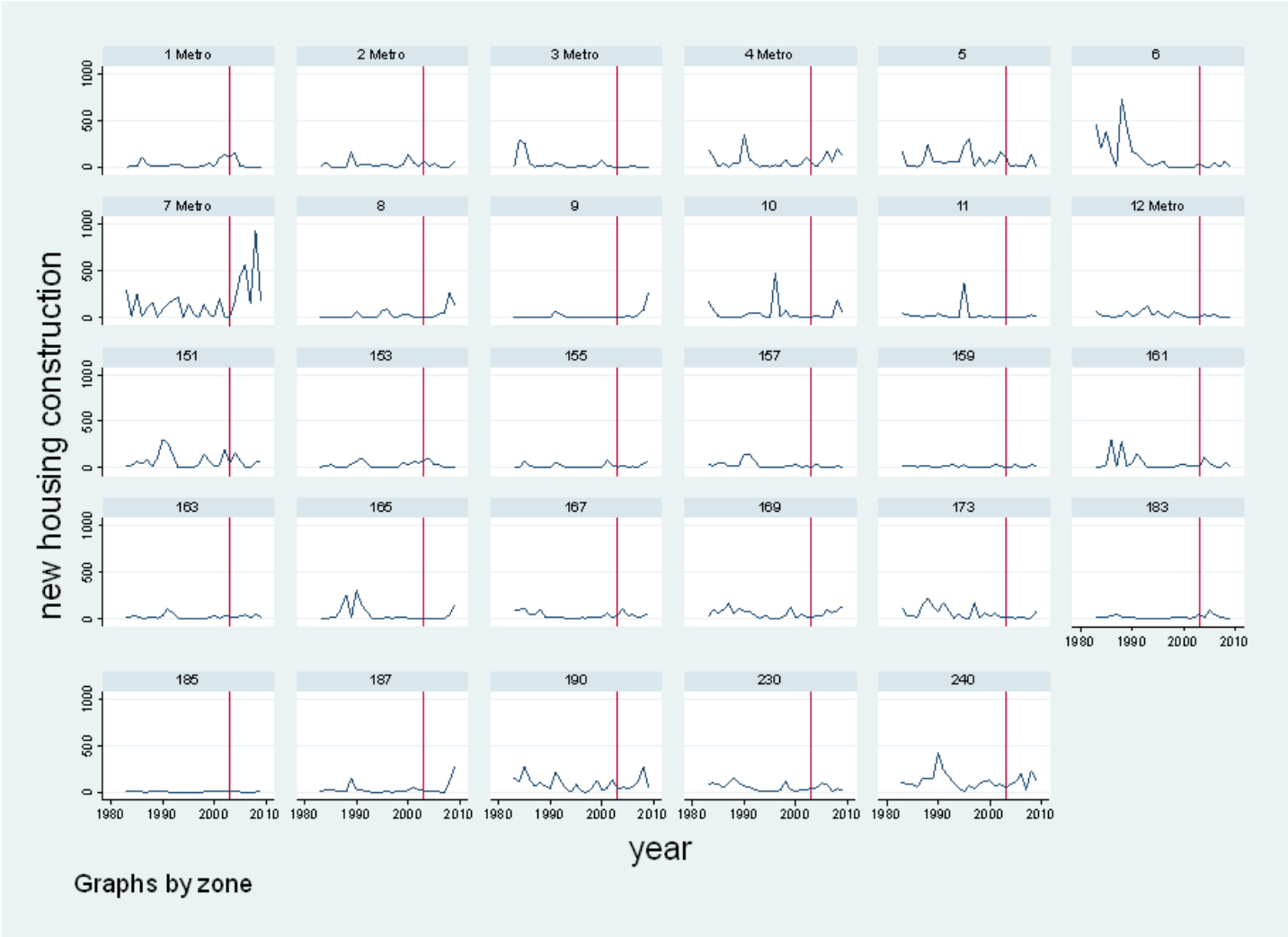


Notes: High education includes bachelor, long-cycle higher education and PhD-degree. The red vertical line indicates the introduction of the metro network.

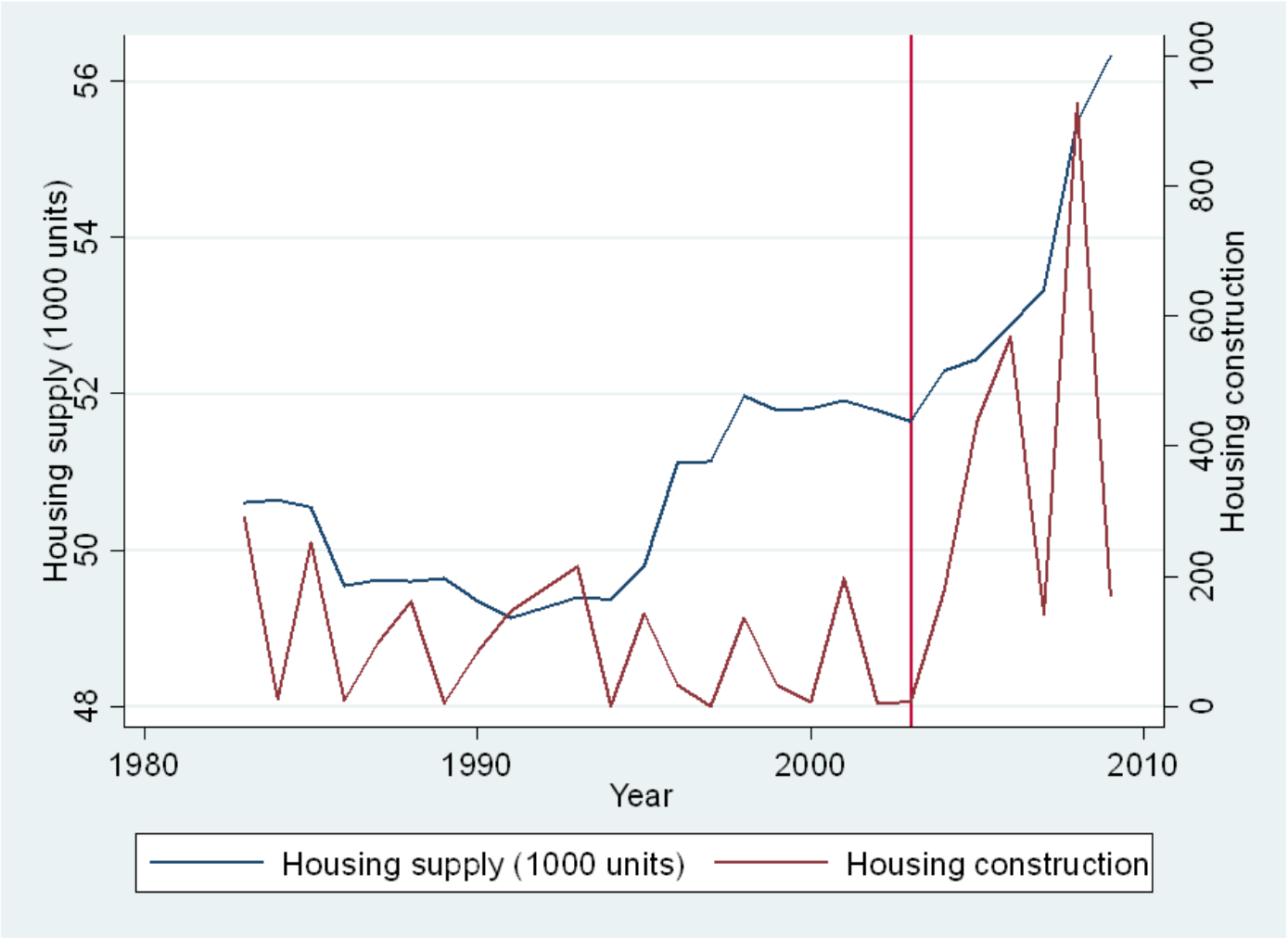
Total housing supply by GCA zones



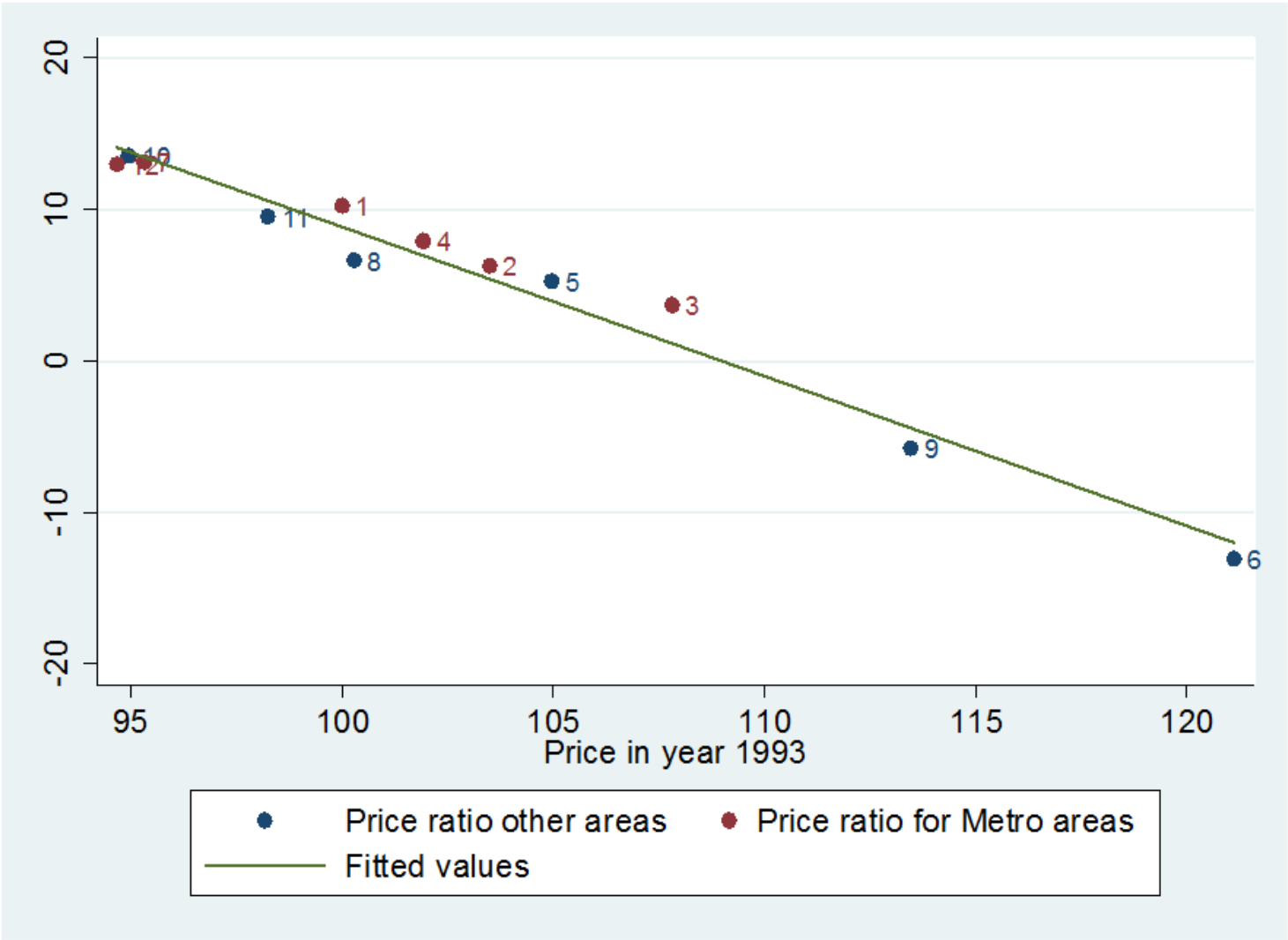
The supply of new housing by GCA zones



Total housing supply and the supply of new housing in Copenhagen S (zone 7)



House prices and gentrification (1993 - 2013)



Share of renters and homeowners by GCAs zones

Gravity model

- Gravity equations are standard tools for the analysis of spatial relationships like trade flows and migration flows (Head and Mayer, 2015)
- The emerging literature on quantitative spatial economics has also use them to model commutes (Ahlfeldt et al. (2015), Monte, Redding and Rossi-Hansberg (2016) and Allen and Arkolakis (2016))
- Often derived from an underlying model of RUM first presented by Eaton and Kortum (2002) - isomorphic to McFaddens (1974) MNL
- Can be regarded as the core of the urban economic models build in the quantitative spatial economics papers as it connects the jobs and the houses $\Rightarrow$ the attractiveness of zones are summarized in a single parameter

A simple commuting model

Focus on commutes - an elementary representation of a city

- Workers choose a combination of residential and work locations
- The attractiveness of a combination depends on:
  - the attractiveness of the residential location a_i
  - the attractiveness of the work location b_j
  - the attractiveness of the combination:
    - a deterministic component associated with travel costs c_{ij}
    - a random component associated with idiosyncratic preferences ε_{ij}
- With ε_{ij} iid EV Type I distributed, this leads to a gravity equation for commuting:

$$\ln \Pi_{ij} = a_i + b_j - c_{ij} + \varepsilon_{ij} \tag{1}$$

Specification of the travel cost function

- We have information on travel times by car and public transport
- A linear specification:

$$c_{ij} = \gamma_c tt_c + \gamma_p tt_p \tag{2}$$

Interpretation: first order approximation to the indirect utility of a mode choice model $\ln\left(e^{\rho_0+\rho_c tt_c+\rho_p tt_p}\right)$

Average travel times have decreased (mostly for public transport

Change in travel times

	Year=2002		Year=2010	
	Mean	Std. dev.	Mean	Std. dev.
Unweighted				
Travel time with car (minutes)	16.753	7.363	17.063	7.672
Travel time with public transport (minutes)	40.972	13.227	38.620	13.424
Weighted by commuting flows				
Travel time with car (minutes)	14.327		13.694	
Travel time with public transport (minutes)	35.755		32.000	

A simple commuting model

MNL estimates

	[1] Year 2002	[2] Year 2010
Travel time with car (minutes)	-0.0336***	-0.0515***
	(0.0012)	(0.0010)
Travel time with public transport (minutes)	-0.0404***	-0.0463***
	(0.0006)	(0.0006)
Log likelihood	-1,054,617	-1,099,951
Number of obs.	169,816	178,988

An increasing resistance against long commutes for both modes, but especially for car travel

How important was the metro?

- Two hypotheses:
  1. Travel time reductions for commutes connecting zones with a metro station in **origin and destination** can be attributed to metro
  2. Travel time reductions for commutes connecting zones with a metro station in **origin or destination (or both)** can be attributed to metro

Important decrease in travel times

FE models for changes in travel times

Travel time with public transport	[1]	[2].	[3]
Origin and destination connected by metro	-4.006***		-0.881***
	(0.466)		(0.297)
Metro station in origin or destination (or both)		-4.786***	-4.688***
		(0.117)	(0.121)
Dummy representing year 2010	-2.192	-0.630***	-0.630***
	(0.093)	(0.070)	(0.070)
R^2	0.0296	0.0800	0.0846
n	1800	1800	1800

Implied changes in commuting flows

- If the supply of housing and jobs were **completely elastic**, the simple commuting model would predict the increase in commuting flows
- **If these assumptions are invalid**, the predicted increases give *an indication of the pressure on the local housing and labor markets* caused by the introduction of the metro

Infinitely elastic housing supply and labour demand

Predicted impact of the metro on commuting flows

	O and D	O or D	
Relative change in commuting flows	[1]	[2]	[3]
Origin and destination connected by metro	0.282***		0.038***
	(0.02)		(0.012)
Metro station in origin or destination (or both)		0.229***	0.225***
		(0.005)	(0.005)
Constant	-0.017**	-0.083***	-0.083***
	(0.0005)	(0.03)	(0.072)
R^2	0.938	0.725	0.728
n	900	900	900

Actual changes in commuting flows are smaller

FE models of the commuting flows

Relative change in commuting flows	[1]	[2]	[3]
Origin and destination connected by metro	0.183***		0.123*
	(0.072)		(0.074)
Metro station in origin or destination (or both)		0.103***	0.089***
		(0.029)	(0.030)
Constant	0.025*	-0.005	-0.005***
	(0.014)	(0.018)	(0.018)
R^2	0.018	0.017	0.017
n	900	900	900

Inelastic supply

- Number of houses and jobs remains unchanged
- Attractivity coefficients a_i and b_j adjust so as to restore the balance between supply and demand
  - $\Rightarrow$ changes in house prices and wages

Burden of adjustment is (predominantly) on housing

Predicted changes in attractiveness

	Origin and destination		Origin or destination	
	res	empl	res	empl
	[1]	[2].	[3]	[4]
Metro station	-0.092***	0.112	-0.112***	-0.015
	(0.007)	(0.139)	(0.012)	(0.062)
Constant	0.120***	0.100	0.127***	0.240***
	(0.003)	(0.062)	(0.005)	(0.062)
R^2	0.852	0.023	0.753	0.000
n	30	30	30	30

Extended commuting model

- The gravity (MNL) model
- Households heterogeneity: "horizontal" sorting model of the type proposed by Bayer and Timmins (2007) and Kuminof et. al. (2013)
- Add cross-terms of characteristics of households and alternatives (amenities)
  - gives individual-specific deviations from average utility
  - important - for instance if higher educated have a strong preference for city centre amenities, etc.

Household micro data

- We use the GCA population living in owner-occupied housing - the data derived from the administrative register data for two years: 2002 and 2010
- We distinguish between living in a house or an apartment and between being a car owner or not in both housing situations
- We focus on two groups: single earner households and dual earners households
- The socioeconomic variables: age, highest education obtained, number of children in household, and dummy variable indicating singles (single earner households)

The composition of owner-occupiers in 2002 and 2010

- The composition of owner-occupiers changed significantly from 2002 to 2010
- The number of single earner households **decreased** by 3.1% while the number of dual earners households **increased** by 8.6%
- The total number of households grew by 3.6%
- Car-ownership is also higher in 2010 compared to 2002

Urban amenities

- Standardized house and apartment prices (from the two separated hedonic models, i.e. one for the houses and one for the apartments)
- Proximity to the nearest metro station (km)
- Number of conserved/protected buildings per sq.km.
- Forest area
- Distance to the CBD
- Standardized hourly wage (DKK)
- Number of jobs (FTE)
- Share of FTE in manufacturing

Gentrification and commuting

Low education

	2002	2010	Change	Deviation from the average
Residence city - Work city	14,151	12,230	-14%	0%
Residence city - Work suburbs	8,243	6,395	-22%	-9%
Residence suburbs - Work city	27,126	21,352	-21%	-8%
Residence suburbs - Work suburbs	47,695	44,509	-7%	6%
Total	97,215	84,486	13%	

Medium education

	2002	2010	Change	Deviation from the average
Residence city - Work city	7,611	8,757	15%	3%
Residence city - Work suburbs	3,752	4,695	25%	13%
Residence suburbs - Work city	11,716	11,131	05%	-17%
Residence suburbs - Work suburbs	19,389	23,107	19%	7%
Total	42,468	47,690	12%	

High education

	2002	2010	Change	Deviation from the average
Residence city - Work city	7,135	12,700	78%	23%
Residence city - Work suburbs	3,054	5,031	65%	9%
Residence suburbs - Work city	10,477	14,519	39%	-17%
Residence suburbs - Work suburbs	9,467	14,566	54%	-2%
Total	30,133	46,816	55%	

Decomposition of the mean utilities (single wage-earners)

	Without household heterogeneity		With household heterogeneity	
	[1] FE	[2] FE	[3] FE	[4] FE
Delta price	-0.100***	-0.101***	-0.895***	-0.896***
	(0.036)	(0.033)	(0.038)	(0.037)
Delta proximity to the nearest Metro station (km)		0.006*		0.007*
		(0.003)		(0.004)
Dummy representing year 2010	0.244***	0.159***	0.665***	0.541***
	(0.033)	(0.056)	(0.037)	(0.068)
R-squared	0.0468	0.0270	0.3307	0.3377
No. of observations	232	232	232	232

Notes: the dependent variable is the vector of mean indirect utilities that were estimated as alternative specific constants related to the residential place locations in the first (logit) step of the estimation procedure; standard errors in parentheses; ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively.

Decomposition of the mean utilities (dual wage-earners)

	Without household heterogeneity		With household heterogeneity	
	[1] FE	[2] FE	[3] FE	[4] FE
Delta price	-0.093*	-0.093*	-0.213***	-0.212***
	(0.048)	(0.048)	(0.049)	(0.049)
Delta proximity to the nearest Metro station (km)		0.012**		0.004
		(0.005)		(0.003)
Dummy representing year 2010	0.035	-0.132	0.114**	0.076
	(0.048)	(0.081)	(0.048)	(0.055)
R-squared	0.0010	0.0333	0.2243	0.2209
No. of observations	344	344	344	344

Notes: the dependent variable is the vector of mean indirect utilities that were estimated as alternative specific constants related to the residential place locations in the first (logit) step of the estimation procedure; standard errors in parentheses; ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively.

Interaction parameter estimates (single wage-earners)

Urban amenities at the residence location: single earner households

	Number of children	Singles	**High education**
Number of conserved/protected buildings per sq.km.	0.568***	0.530***	**1.983*** **
	(0.040)	(0.072)	**(0.083)**
Distance to the CBD.	0.022***	0.002	**-0.105*** **
	(0.002)	(0.003)	**(0.004)**
Distance to the CBD.* dummy indicating car ownership	-0.005***	-0.017***	**0.012*** **
	(0.002)	(0.003)	**(0.003)**
Standardized house price (mio. DKK)	0.073***	0.121***	**0.676*** **
	(0.016)	(0.029)	**(0.035)**

Urban amenities at the workplace location: single earner households

	Male	Singles	**High education**
Number of Full Time Equivalents (1000 FTE pr. sq.km.)	-0.008***	-0.006***	**0.032*** **
	(0.001)	(0.002)	**(0.002)**
Share of FTE's in manufacturing	0.265*	-0.037	**-0.455** **
	(0.145)	(0.162)	**(0.200)**
Wage	0.020***	0.003	**0.026*** **
	(0.002)	(0.002)	**(0.003)**
Distance to the CBD	0.013***	-0.010***	**-0.016*** **
	(0.002)	(0.003)	**(0.003)**

Conclusions

- This paper analyses the impact of the introduction of the metro network on the Copenhagen metropolitan area
- We find:
  - a significant impact of the metro on the travel times of commutes and commuting flows
  - the increasing interest of the higher educated in urban amenities - gentrification - likely caused by a greater interest in living and working in the neighborhoods where a metro station is present
- Empirical results also suggest that not only housing prices and wages, but also quantities react to the metro and that the larger burden of adjustment is on the housing market