THE EFFECTIVE DENSITY ELASTICITY OF PRODUCTIVITY FOR MOVERS AND STAYERS

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BRIEF
motivation I

- **80% of world's GDP generated in cites**
  - External returns to density
  - Sharing, matching, learning…
- ***Density elasticity of productivity*** **is of central academic and policy interest**
  - **Large academic literature on causes and effects of agglomeration**
  - **External returns imply role for policy**
    - Land use and transport policies
- **Density is correlated with many other things…**
  - Fundamentals, talent, infrastructure, etc.
  - **Interested in the causal effect of density on productivity!**

BRIEF

motivation II

- **Empirical challenge is to control for unobserved heterogeneity**
- **Literature focuses on individual abilities to mitigate sorting concerns**
  - Studies in the tradition of Combes, Duranton, Gobillon (2008) control for individual FE (first proposed by Glaeser and Mare, 2001)
  - **Results in an ATT for between-municipality movers**
    - **If movers are "special", ATT ≠ ATE**

Problem

- **This paper proposes a new estimation strategy**

Solution

  - **Observe individuals repeatedly over time, subject to exogenous changes in effective density from transport improvements**
    - Effective density: Labour force within a 60 min one-way commute
  - **Can estimate causal *ATE*, *mover ATT*, and *stayer ATT***

BRIEF

motivation III

- As of 2019, **67** academic analyses of density elasticities of productivity (Ahlfeldt and Pietrostefani, 2019)
- **1) Early estimates: ≈ 0.06** (e.g. Ciccone & Hall, 1996)
  - **ATE from cross-sectional research design** (IV to address fundamentals)
  - **Problems with sorting and unobserved individual skills**
- **2) Recent estimates: ≈ 0.03** (e.g. Combes et al, 2008)
  - **ATT for movers, controlling for unobserved individual effects**
- **3) This paper: ≈ 0.012** *(new)*
  - **ATE, controlling for individual, location, and establishment effects**
  - ***Mover ATT: 0.025*** *(confirms consensus)* ***vs. stayer ATT: 0.011*** *(new)*
    - **Difference due to skill-biased returns to agglomeration!**

We get an ATE that is 50% lower than the ATT from the consensus strategy!

BRIEF
structure

- **A Theoretical framework and estimation strategy**
- **B Empirical setting**
  - Transport improvements
  - Data
- **C The effective density elasticity of productivity**
  - Mover ATT vs. ATE
  - Aggregate productivity effects
- **D Selection effects**
  - Workers, firms, locations
- **E Fundamental effects**
- **F Conclusion**

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PRODUCTION FUNCTION

theoretical framework

- **Conventional Cobb-Douglas production function with capital (K) and labour (L) inputs and TFP shifter (A)**
  - *c* indexes locations, *t* indexes time, m indexes groups of establishments *j*, *g* indexes groups of workers *i*

$$Y_{ct} = \frac{A_{c(j)m(j)t}}{\alpha^{\alpha}(1-\alpha)^{(1-\alpha)}}\left(S_{c(i)g(i)t}L_{ct}\right)^{\alpha}K_{ct}^{(1-\alpha)}$$

- **Profit maximization and zero profits (spatial equilibrium)**

TFP

Labour productivity

Wages

$$w_{c(i,j)m(j)g(i)t} = A_{c(j)m(j)t}^{\frac{1}{\alpha}}S_{c(i)g(i)t}$$

PRODUCTION FUNCTION

theoretical framework

- **Labour productivity**

Worker composition effect

$$S_{c(i)g(i)t} = s_{c(i)t} D_{ct}^{\gamma_{g(i)}}$$

Density effect varies across woker groups

Density

- **Total factor productivity**

$$A_{ct} = h_{c(j)t} f_c a_t D_{ct}^{\beta_m(j)}$$

Density effect varies across establishment grups

Establishment composition effect

Fundamental effects

- **Worker-establishment-composition-adjusted wages**

First-nature effect

$$\ln w_{c(i,j)m(j)g(i)t} - \ln s_{c(i)t} - \frac{1}{\alpha} \ln h_{c(j)t} = \ln f_c \frac{a_t}{\alpha} + \left(\gamma_{g(i)} + \frac{\beta_{m(j)}}{\alpha} \right) \ln D_{ct}$$

Second-nature effect

COMPOSITION AND FUNDAMENTAL EFFECTS

theoretical framework

- **AKM wage decomposition in first-stage regression:**

Worker fixed effects **Establishment fixed effects**

$$\ln w_{ijct} = \theta_{ct} + z_{it}\xi + \pi_i + \vartheta_j + \varepsilon_{ijct}$$

Error term 1

Municipality-year effects **Worker observables**

- **Define worker-establishment-composition-adjusted municipality-year wages**

$$\ln w_{c(i,j)m(j)g(i)t} - \ln s_{c(i)t} - \frac{1}{\alpha}\ln h_{c(j)t} \equiv \ln w_{ijct} - z_{it}\xi - \pi_i - \vartheta_j$$

- **Define fundamental productivity as:**

Region (East vs. West)-year effect

$$\ln f_t \frac{a_t}{\alpha} = \omega_c + \varphi_c \nu(t) + \Upsilon_{rt} + \epsilon_{ct}$$

Error term 2

Time-invariant fixed effect **Trend effect**

EMPIRICAL SPECIFICATION

empirical strategy

- **Combine ingredients to get reduced-form specification**

$$\theta_{ct} = b_{g(i)m(j)} \cdot \ln D_{ct} + \omega_c + \varphi_c \nu(t) + \Upsilon_{rt} + e_{ct}$$

$$e_{ct} = \epsilon_{ct} - \bar{\varepsilon}_{ct} \qquad b_{g(i)m(j)} = \gamma_{g(i)} + \frac{\beta_{m(j)}}{\alpha}$$

Labour share: 0.67

Density elasticity of *labour productivity*

- **Estimating equation in first differences**

$$\Delta\theta_{ct} = b_{g(i)m(j)} \cdot \Delta \ln D_{ct} + \varphi_c + \widetilde{\Upsilon}_{rt} + \Delta e_{ct}$$

Linear trend in baseline, higher-order polynomials in robustness checks

EFFECTIVE DENISTY

key variable

- **Effective density: Labour force within commuting range**

$$D_{ct} = \sum_s E^R_{st} \cdot \mathbb{1}(\tau_{cst} \leq T)_t$$

Labour force at commuting origin s

Indicator function, 1 if travel time < threshold T

- **Use IV to restrict identifying variation to variation over time from τ_{cst}**

$$D^{IV}_{ct} = \sum_s \bar{E}^R_{s} \cdot \mathbb{1}(\tau_{cst} \leq T)_t$$

- **Removes concern about correlated unobserved shocks (in space and time) ϵ_{ct} that may impact on E^R_{st} leading to violation of $cov(e_{ct}, D_{ct}) = 0$**

DENSITY ELASTICTY OF LABOUR PRODUCTIVITY

empirical strategy

- **Density elasticity of labour productivity specific to**
  - **Workers** (direct worker productivity effect, via S)
  - **Establishments** (via TFP A)
  - **Interaction effect** with density**, not a level (sorting) effect** (in fixed effects)

$$b_{\boxed{g(i)m(j)}} = \gamma_{\boxed{g(i)}} + \frac{\beta_{\boxed{m(j)}}}{\alpha}$$

- **Estimate ATE as the average over all workers in all establishments**
  - **Assortative matching** (Daut et al 2018) implies $\boldsymbol{cov(A_{c(m)}, S_{c(g)}) > 0}$
  - Any **ATT** for groups of workers or establishment is ***g(i)-m(j)*-specific**
- **Use the ATE to compute the density elasticity of output**

$$\beta_{m(j)} + \alpha\gamma_{g(i)} = \alpha b_{g(i)m(j)}$$

EMPIRICAL SETTING

structure

- **A Theoretical framework and estimation strategy**
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  - Transport improvements
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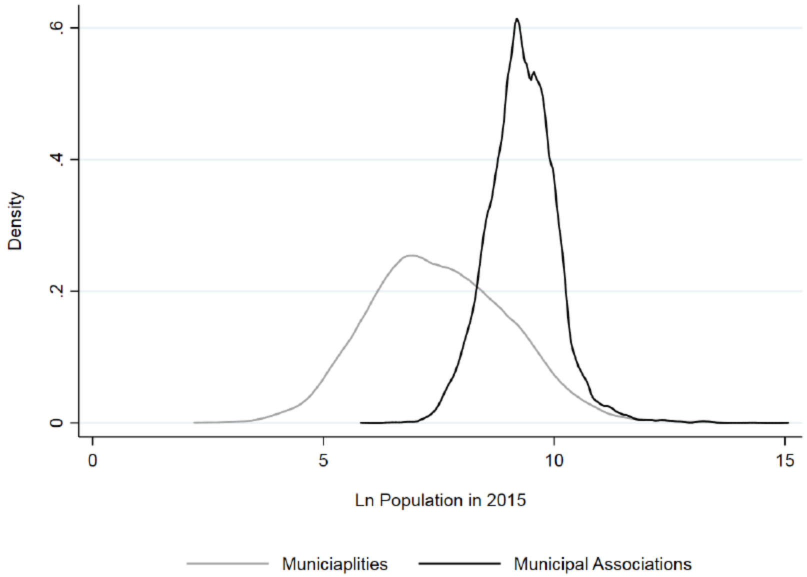
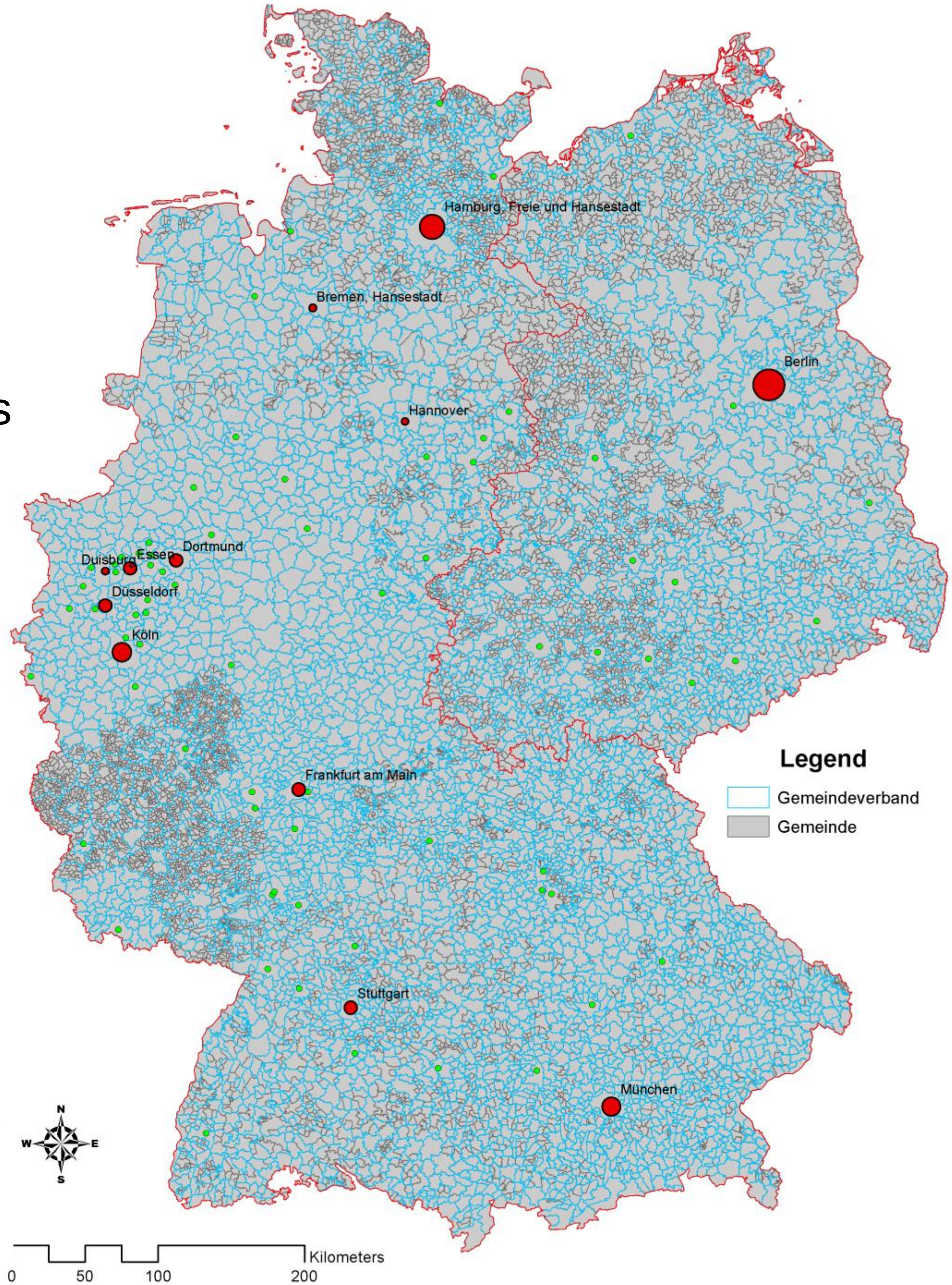
UNIT OF ANALYSIS

geography

- **Municipalities definition**
  - 4462 municipal associations ("Verbandsgemeinden")
  - Aggregated from about 11k independent munis. ("Gemeinden")





LABOUR MARKET DATA

from IAB

- **Matched employer-employee data set from Federal Employment Agency**
- **Universe of worker: We draw a random 2% sample (to be increased)**
  - **About 30M employees (subject to social security)**
    - Repeatedly observed throughout the study period
    - Workplace
    - Residence

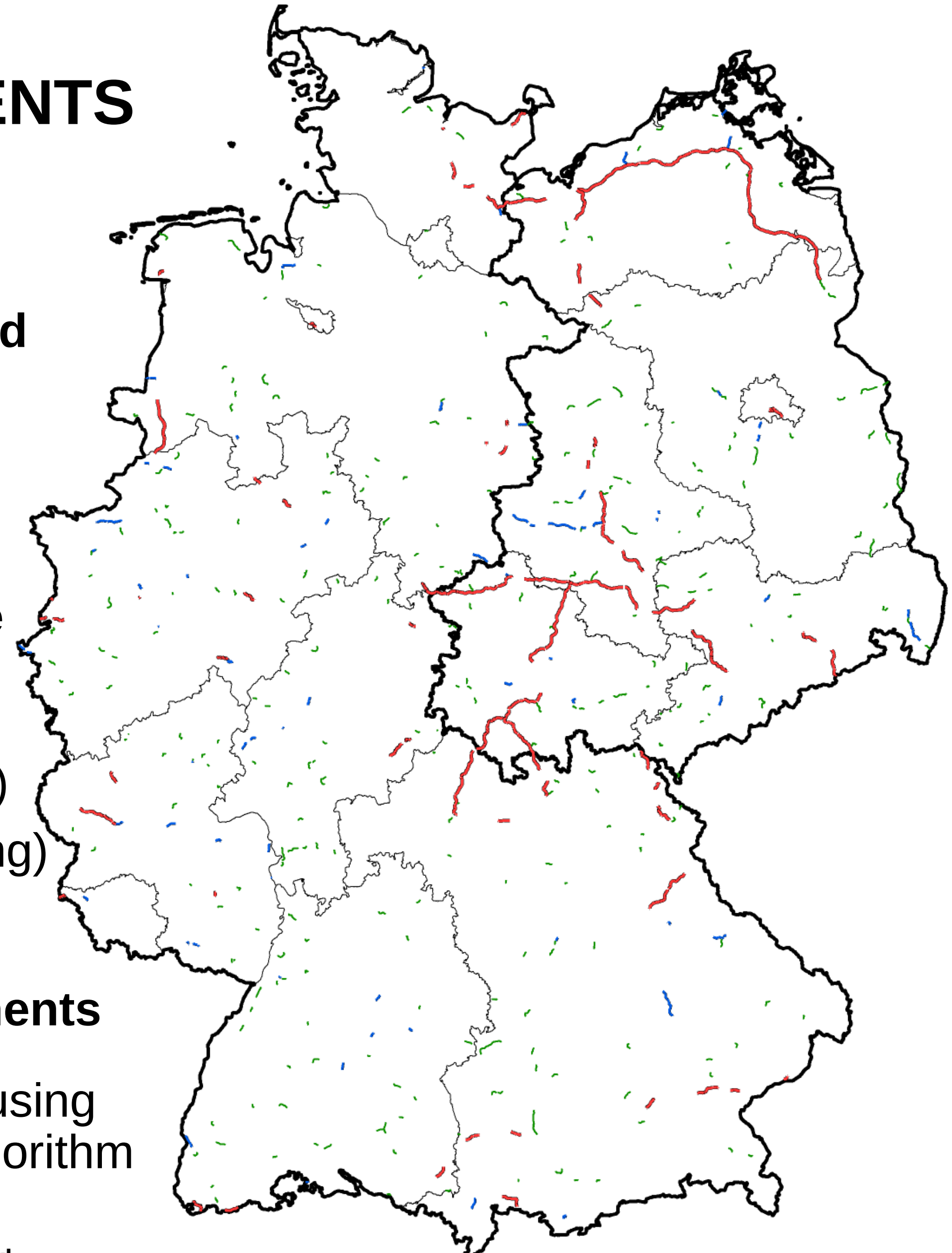
    Commuting

    - Wage and other observables (age, gender, tenure, etc.)
    - Individual identifier
  - **3M establishment (plants)**
    - Unique establishment identifier
  - **All matched to 2015 municipality boundaries**

TRANSPORT IMPROVEMENTS

data collection

- **Start from <u>2015</u> transport map and adjust for years back to <u>1999</u>**
- **Hand-collected data from government reports**
- **Delete new segments from shape**
  - 1,379 km highways (Autobahn)
  - 391 km a road (Bundesstrasse)
  - 1,214 km b road (Ortsumgehung)
  - 944 km HSR (high-speed ICE)
- **Assign speeds to transport segments**
- **Solve travel time** by road and rail using Huber and Rust's (2016) routing algorithm



AGGREGATING TRAVEL TIMES BY ROAD AND RAIL

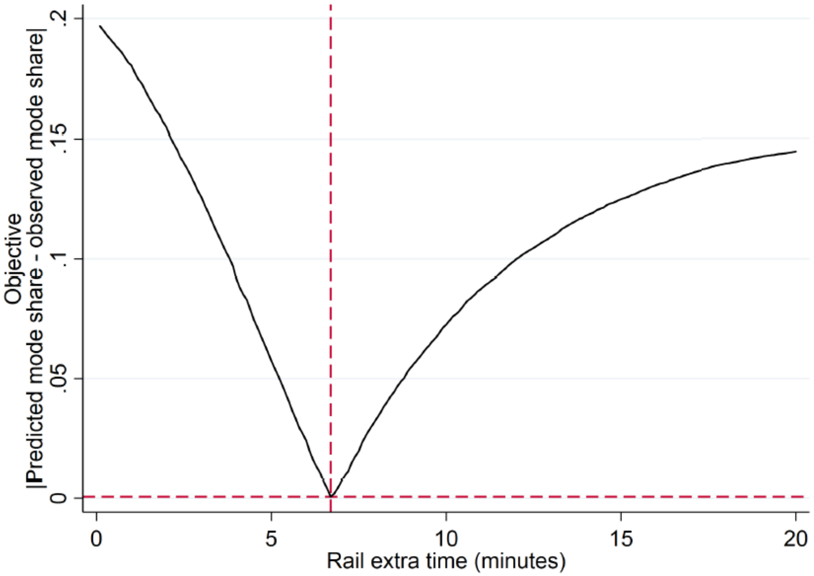
data processing

- **O-D travel time is minimum of road and rail time, accounting for relative extra cost *z***

$$\tau_{cs} = min(\tau_{cs}^{CAR}, \tau_{cs}^{TRAIN} + z),$$

- **Identify *z* by matching aggregate modal split**

$$RS^{z} = \frac{\sum_c \sum_s C_{cs} \cdot \mathbb{1}(\tau_{cs}^{TRAIN} + z < \tau_{cs}^{CAR})}{\sum_c \sum_s C_{cs}}$$



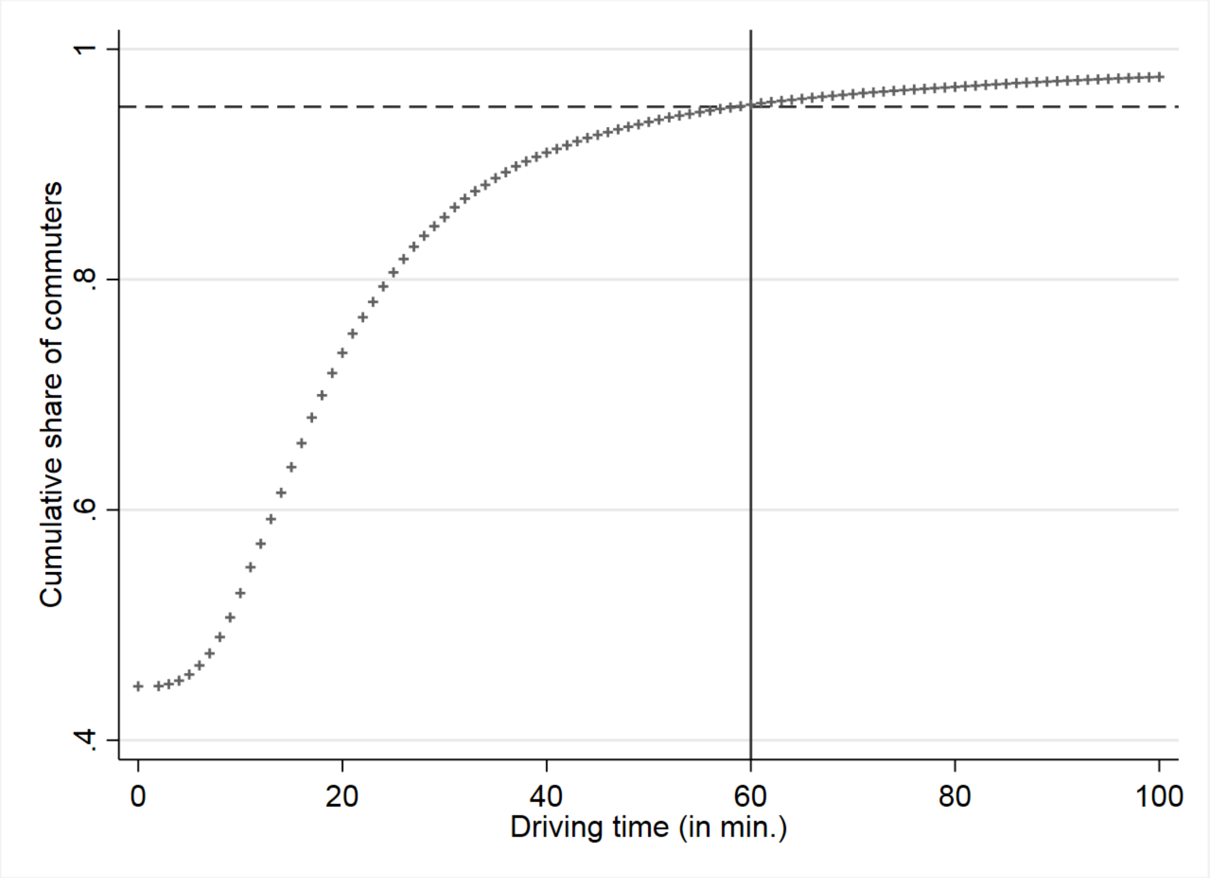
Notes: Rail extra time that minimizes objective is 6.7 minutes.

- **Clearly defined minimum in the objective function at *z*=6.9 minutes** (extra time for waiting at station, getting from station to centre)

DISTRIBUTION OF COMMUTING TIMES

defining local labour markets

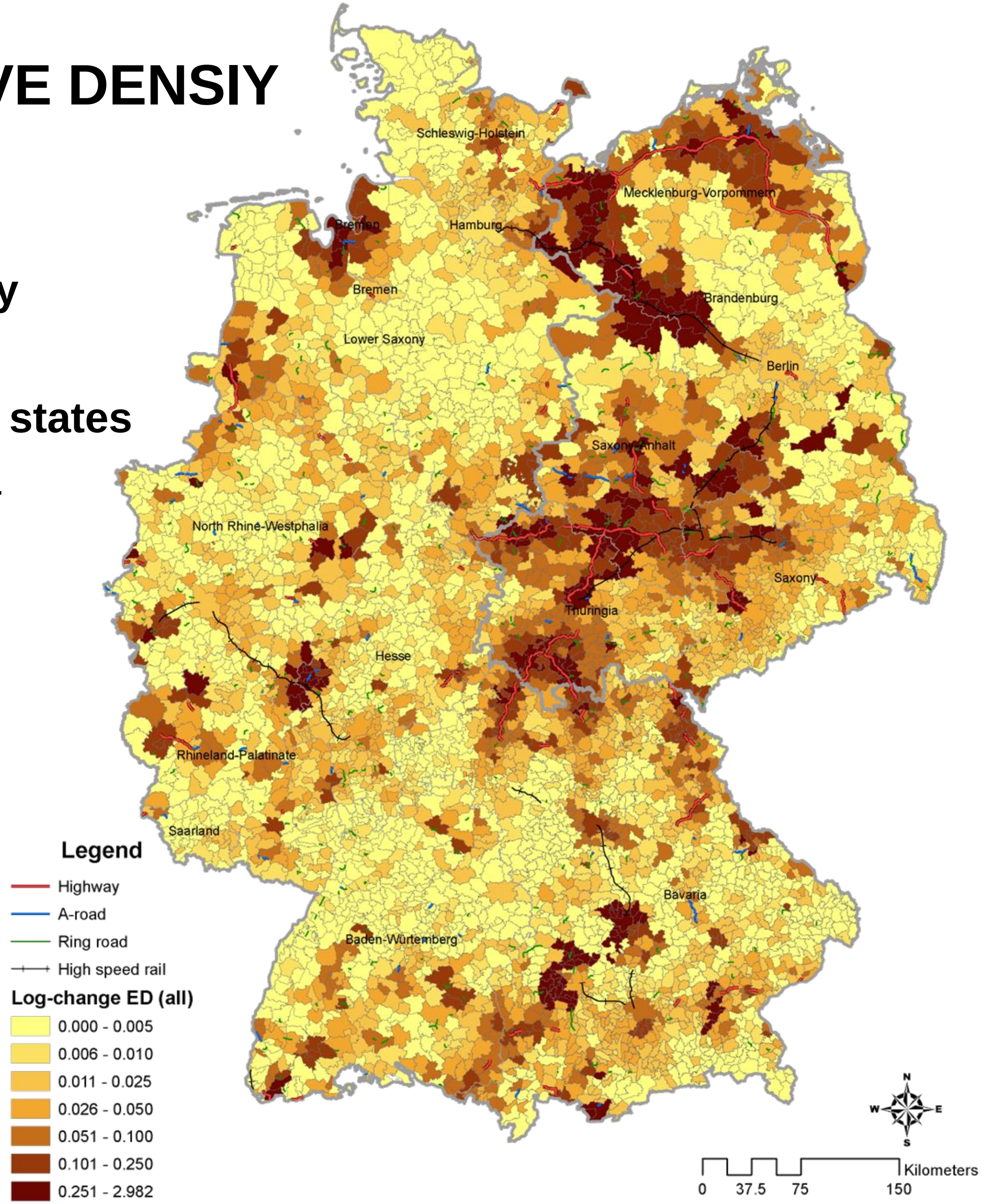
- **At *T*=60 minutes, we cover 95% of commuters**



CHANGE IN EFFECTIVE DENSIY

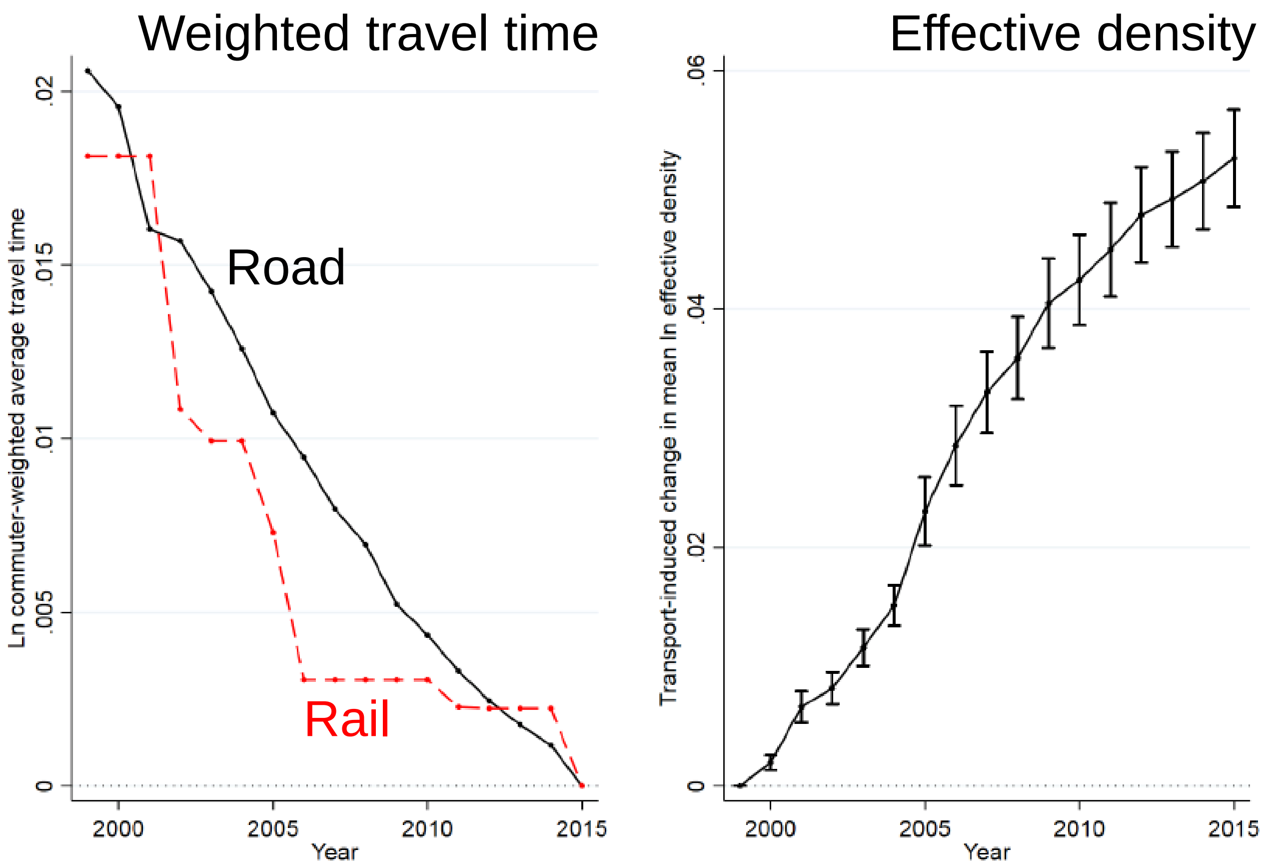
1999 to 2015

- **Changes in effective density throughout the country**
- **Biased towards the eastern states**
    - (identification controls for East-West convergence)
- **Large improvements from**
    - **Highways**
    - **HSR**



CHANGE IN EFFECTIVE DENSITY

year-on-year changes



Notes: Left panel shows the commuter-weighted average travel time between all municipality pairs in a year by car (solid black line) and rail (dashed red line). Right panel illustrates the evolution of transport induced effective density. Point estimates and confidence bands are recovered from a regression of the effective density IV defined in equation 11 against municipality fixed effects and year effects.

MAIN RESULTS

structure

- A Theoretical framework and estimation strategy
- B Empirical setting
  - Transport improvements
  - Data
- **C The effective density elasticity of productivity**
  - Mover ATT vs. ATE
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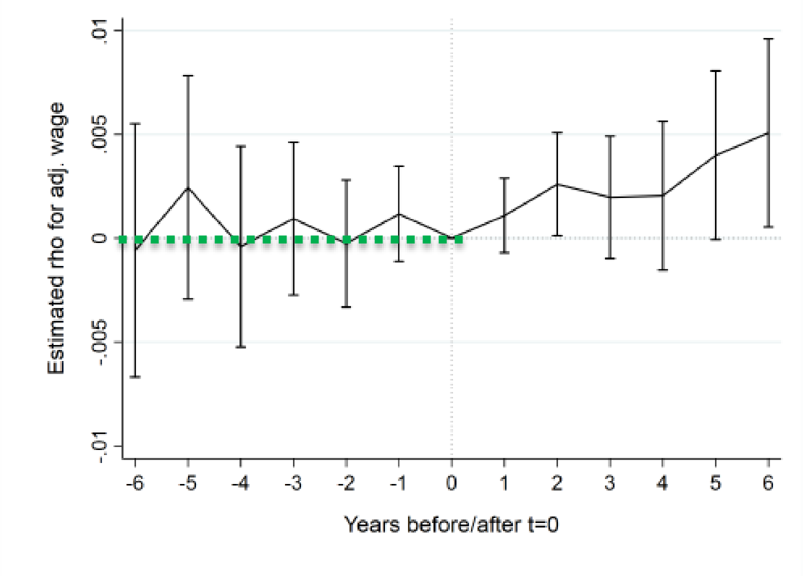
EVENT STUDY

pre-trend evaluation

- **Key identifying assumption is that changes in effective density are uncorrelated with shocks conditional on trend control**
- **Event-study: Treatment is having an improvement within 25 km**



(a) All Periods

Note: Panel A considers all periods and Panel B splits the period into and early period from 1999—2007 (black) and a late period from 2008–2015 (red).

DENSITY ELASTICITY OF PRODUCTIVITY

consensus vs. new approach

	Consensus approach with actual density		Consensus approach with effective density		New approach with effective density		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Ln adjusted wages			
Ln density (b)	0.069*** (0.01)	0.026*** (0.00)	0.058*** (0.00)	0.026*** (0.00)	0.022* (0.01)	0.017*** (0.01)	0.012** (0.00)
Density elasticity of TFP (β)	0.046	0.017	0.039	0.017	0.015	0.011	0.008
Measure	Labor force in LMA		Labour force within 60 minutes				
Units	141 LMA	141 LMA	4449 Mun.	4449 Mun.	4447 Mun.	4447 Mun.	4445 Mun.
Periods	1 cross-section	1 cross-section	1 cross-section	1 cross-section	16 years	16 years	16 years
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual effects	-	Yes	-	Yes	-	Yes	Yes
Estab. Effects	-	-	-	-	-	-	Yes
Ln area control	Yes	Yes	-	-	-	-	-
Muni. fixed eff.	-	-	-	-	Yes	Yes	Yes
Muni. trends	-	-	-	-	Yes	Yes	Yes
Region fixed eff.	Yes	Yes	Yes	Yes	-	-	-
Region-period eff.	-	-	-	-	Yes	Yes	Yes
Identification from	All	Movers	All	Movers	All	All	All
N	141	141	4449	4449	70305	70291	70220

Notes: IV estimates in models (5-8). Unit of observation is labour market area in (1) and (2), municipalities in (3) and (4), and municipality-period (years) in the subsequent models. β is the density elasticity of productivity. Municipality trends are included by estimating the model in first differences and adding municipality fixed effects. Effective density in a given period is total residence employment within 60 min travel time in that given period. Instrument for effective density is the sum of the (time-invariant) residence employment in municipalities within 60 minutes (time varying). Adjusted wages are Mincer-adjusted for observable characteristics and the indicated first-stage fixed effects. Region fixed effects and region x period effects separate fixed effects and time effects for western and eastern states. Standard errors clustered on municipalities. $^{+}p < 0.15, ^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$

CONSENSUS ESTIMATES

cross-sectional variation in density

	Consensus approach with actual density		Consensus approach with effective density	
	(1)	(2)	(3)	(4)
			Ln adjusted wages	
Ln density (b)	0.069*** (0.01)	0.026*** (0.00)	0.058*** (0.00)	0.026*** (0.00)
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Individual effects	-	Yes	-	Yes
Estab. Effects	-	-	-	-
Ln area control	Yes	Yes	-	-
Muni. fixed eff.	-	-	-	-
Muni. trends	-	-	-	-
Region fixed eff.	Yes	Yes	Yes	Yes
Region-period eff.	-	-	-	-
Identification from	All	Movers	All	Movers
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Effective density and spatially disaggregated data yield results that are directly comparable to consensus approach (separate labour markets)

MOVER ATT VS ATE ESTIMATE

consensus vs. new approach

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			Consensus approach with effective density		New approach with effective density		
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Individual effects	-	Yes	-	Yes	-	Yes	Yes
Estab. Effects	-	-	-	-	-	-	Yes
Ln area control	Yes	Yes	-	-	-	-	-
Muni. fixed eff.	-	-	-	-	Yes	Yes	Yes
Muni. trends	-	-	-	-	Yes	Yes	Yes
Region fixed eff.	Yes	Yes	Yes	Yes	-	-	-
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DENSITY ELASTICITY OF PRODUCTIVITY

consensus vs. new strategy

- **New estimate about 50% smaller than consensus estimate**
- **Four not mutually exclusive explanations**

	Consensus estimate	**New estimate**
1) Worker selection	ATT for movers	ATE for movers and stayers
2) Firm selection	Denser places may attract more productive firms	Conditional on etablishment effects
3) Place selection	Identification from all municipalities	LATE for municipalities with transport upgrades
4) Fundamental effects	Density may be correlated with fundamental productivity	Conditional on municipality fixed effects

Previewing our findings: 1) Matters!

ROBUSTNESS

substantiating the main finding

- **Robustness tests**
  - **Varying travel time thresholds T in D**
    - 40, 50, 60, 70, 80, 90 minutes
  - **Varying trend controls**
    - Polynomial orders of 0, 1, 2, 3
  - **Estimates by region**
    - Western states vs. eastern states
  - **Results by variation from different types of infrastructure**
    - Road vs. rail

Results substantiate interpretations qualitatively and quantitatively

AGGREGATE EFFECTS

welfare

- **Simple counterfactual analysis to infer aggregate effects on output**

$$\frac{Y_c'}{Y_c} = \left(\frac{D_c'}{D_c}\right)^{\left(\gamma+\frac{\beta}{\alpha}\right)}$$

Prime denotes levels in counterfactual scenario

- **Under the assumptions made, we have:** $Y_c = \frac{w_c L_c}{\alpha}$
- **Aggregate productivity effect**

$$W^A = \sum_c Y_c' - Y_c = \sum_c \left[\left(\frac{D_c'}{D_c}\right)^{\alpha\hat{b}} - 1\right]\frac{w_c L_c}{\alpha}$$

- **Compare to the value of travel time savings**

$$W^{TT} = \sum_{cs} \left(\tau_{cs,1999} - \tau_{cs,2015}\right) \times V \times H \times C_{cs}$$

V = €10/h (50% of av. wage)
H = 500 (2 commutes per day, 250 per year

AGGREGATE EFFECTS

benefits vs costs

Productivity induced effects on outputs in the range of the VTTS and sizable relative to costs

Wider economic impacts important for transport appraisals

Need to use the ATE: Mover ATT would overstate effects

Panel A: Agglomeration benefits W^A (€)			
Density elasticity of productivity β	0.8%		
Change in market access	112,000,000,000		
Agglomeration benefit	902,000,000		
Panel B: Value of travel time savings W^{TT} (€)			
Value of time (1h)	10		
Total travel time savings (per h)	88,268,043		
	882,680,430		
Panel C: Construction cost (€)			
	Per-km cost	km	Total cost
Highway	10,000,000	1379	13,790,000,000
A-Road	5,000,000	391	1,955,000,000
B-Road	5,000,000	1214	6,070,000,000
High-speed rail	20,000,000	944	20,000,000,000
		Total	40,695,000,000
Annualized total cost (5%)			2,034,750,000
Annualized total cost (3%)			1,220,850,000

Notes: Density elasticity estimate from Table 1, column (7). Change in market access is the sum of the percentage change in effective density multiplied by the regional GDP (see equation 16. Total travel time savings is the sum over the 1999–2015 differences in travel time on bilateral municipality routes multiplied by the number of commuters. We scale up the number of commuters in our data (about 30M) to the labour force (40M). The value of time corresponds to 50% of the average wage. Total km of new infrastructure computed in GIS. Per-km highway cost from Spiegel (2016). We assume half that cost for A- and B-roads since they feature two instead of four lanes. Per-km cost for high-speed rail are from Glover (2009). All figures in 2015 prices.

SELECTION EFFECTS

structure

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ATTs FOR MOVER GROUPS

mover groups

ATT for movers with new approach = ATT from consensus appraoch

	(1)	(2)	(3)	(4)	(5)	(6)
			Ln adjusted wages			
Ln effective density	0.011** (0.005)	0.011** (0.005)	0.009 (0.013)	0.025*** (0.007)	0.003 (0.006)	0.024*** (0.009)
β						
Measure			Effective density			
Muni move	Stayer	Stayer	Stayer	Mover	Mover	Mover
LMA move	Stayer	Stayer	Stayer	Mov. & stay.	Stayer	Mover
Job move	Mov. & stay.	Stayer	Mover	Mover	Mover	Mover
Units						
Periods						
Individual effects	Yes	Yes	Yes	Yes	Yes	Yes
Estab. Effects	Yes	Yes	Yes	Yes	Yes	Yes
Muni. fixed eff.	Yes	Yes	Yes	Yes	Yes	Yes
Muni. trends	Yes	Yes	Yes	Yes	Yes	Yes
Region-period eff.	Yes	Yes	Yes	Yes	Yes	Yes
N	66395	65507	34657	67119	57691	60346

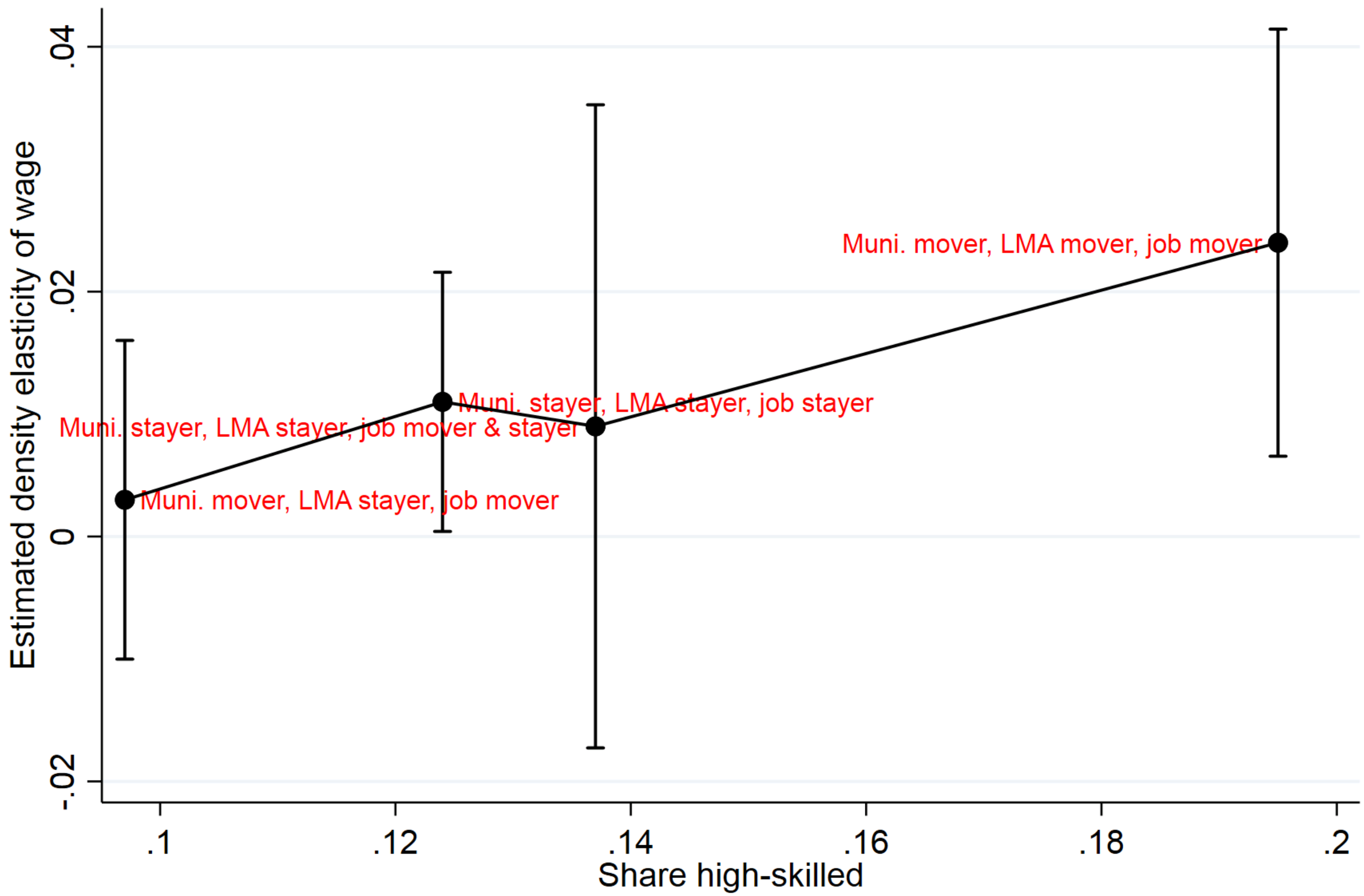
No job mover effect / „generic“ labour market friction

Notes: IV estimates. Unit of observation is municipality-period (years). β is the density elasticity of productivity. Municipality trends are included by estimating the model in first differences and adding municipality fixed effects. Effective density in a given period is total residence employment within 60 min travel time in that given period. Instrument for effective density is the sum of the (time-invariant) residence employment in municipalities within 60 minutes (time varying). Adjusted wages are Mincer-adjusted for observable characteristics and the indicated first-stage fixed effects. Region x period effects separate fixed effects and time effects for western and eastern states. Standard errors clustered on municipalities. $^{+}p < 0.15, ^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$

SKILL-BIASED RETURS TO AGGLOMERATION

density elasticity by mover groups and average skills

Groups with high skills enjoy large returns to density



MOVER CHARACTERISTICS

linear probability models

LMA-movers have better *observed skills* and *unobserved abilities*

Tend to be male, young, working in business services

Profile rationales whyLMA-movers enjoy above-average benefits from density

Move	(1) Job	(2) Job	(3) Muni.	(4) Muni.	(5) LMA	(6) LMA
Ind. fixed effects		0.001		-0.000		0.055***
		(0.000)		(0.000)		(0.000)
	...	...	...	...	...	...
High skilled	0.054***	0.050***	0.054***	0.052***	0.112***	0.090***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	...	...	...	...	...	...
Business services	0.048***	0.047***	0.068***	0.065***	0.086***	0.081***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Public sector	0.001	-0.003***	-0.043***	-0.047***	-0.020***	-0.026***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	4937244	4783346	7484547	7316279	7484547	7316279
R^2	0.166	0.177	0.221	0.23	0.157	0.163

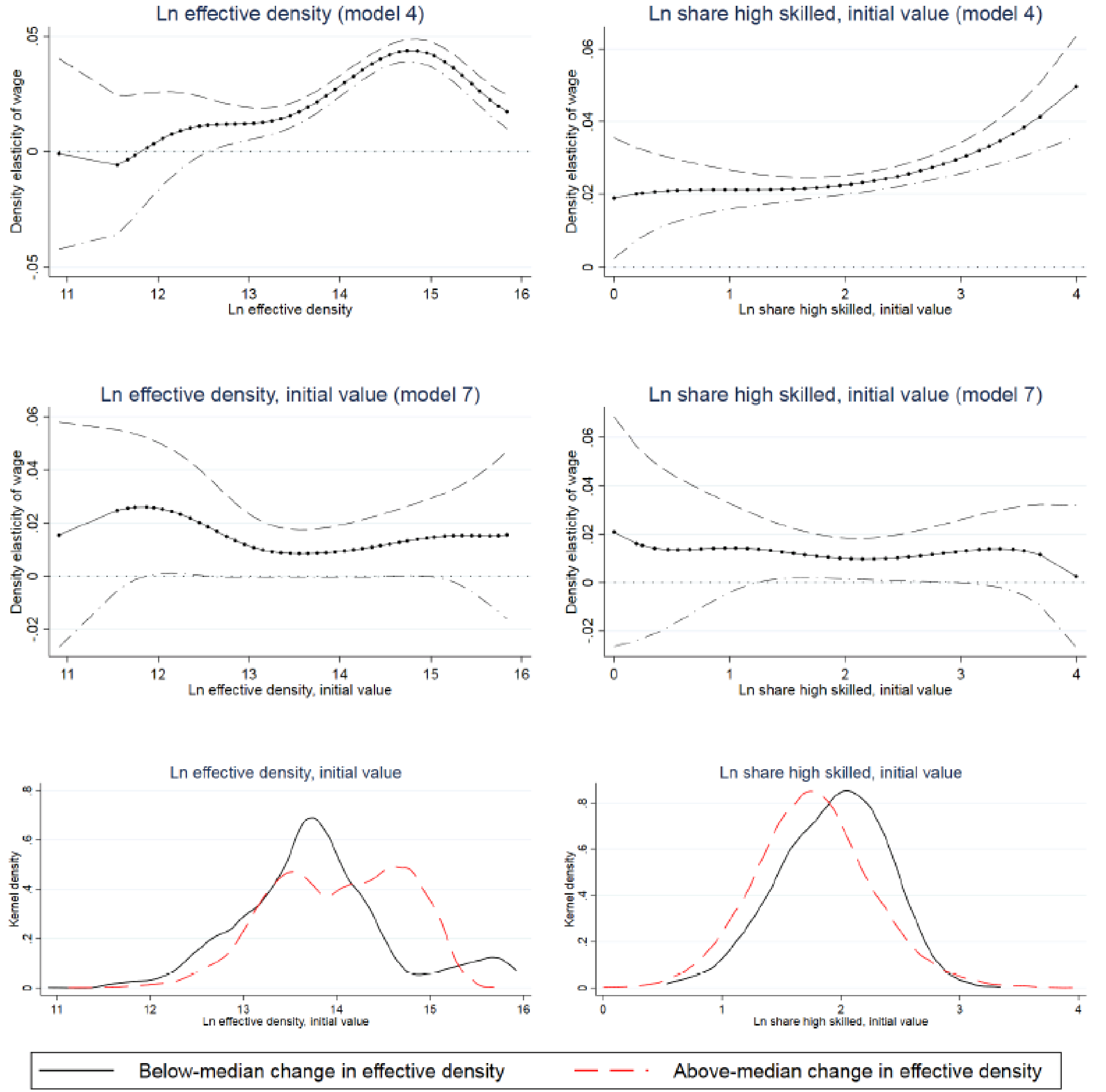
LWR

spatial heterogenetiy

Consensus estimate: Large heterogeneity, due to firm sorting?

Preferred estimates: Little heterogeneity in estimated density elasticity over the relevant parts of the distribution – LATE unlikely

Connected municipalities with greater initial effective density and lower average skill levels – LATE?



FUNDAMENTAL EFFECTS

structure

- A Theoretical framework and estimation strategy
- B Empirical setting
  - Transport improvements
  - Data
- C The effective density elasticity of productivity
  - Mover ATT vs. ATE
  - Aggregate productivity effects
- D Selection effects
  - Workers, firms, locations
- **E Fundamental effects**
- F Conclusion

FUNDAMENTAL EFFECTS

potential OVB in consensus estimate

- **New approach allows separating density and fundamental effects**
  - **Fundamentals may impact on density and productivity**
- **Are consensus estimates biased due to correlated fundamental effects?**

Assume total differential

$$d\theta = \frac{\partial \theta}{\partial \ln D} d \ln D + \frac{\partial \theta}{\partial \ln f} d \ln f$$

Preferred estimate → $\frac{\partial \theta}{\partial \ln D} = \widehat{b}^C - \frac{d\omega}{d \ln D}$ ← $d\omega = \frac{\partial \theta}{\partial \ln f} d \ln f$

Source of bias

Consensus estimate

- ***Recall:* ATT for movers is the same in consensus and preferred strategy**
  - **Expect** $\frac{d\omega}{d \ln D} = 0$
  - **Recover fixed effect from level-level version of baseline model**

FUNDAMENTALS I

correlation between municipality fixed effects and initial effective density

$$\theta_{ct} = b \cdot \ln D_{ct} + \omega_c + \varphi_c \nu(t) + \Upsilon_{rt} + e_{ct}$$

	(1) Fundamental productivity (6)
Ln effective density, $t = 0$	0.007
	(0.01)
	…
First Stage: Pop. Density 1907	0.404**
	(0.019)
K-P rk LM statistic	90.108
K-P rk LM statistic (P-value)	0.000
R^2	0.450
N	4,427

Notes: Instrument for log effective density is 1907 (from the employment census) population density measured at the level of counties. Fixed effects are recovered from a regression of adjusted municipality-year wages (for observables, individual and establishment fixed effects) against effective density (instrumented), municipality-specific linear trends, and fixed effects. Trend effects are recovered as the fixed effects from an analogous regression in first differences, omitting municipality-specific trends. All estimations are conditional on East- and West-specific time trends. Standard errors clustered on the county-level. $^+p < 0.15, ^*p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$

Time-invariant mesurement error in effective density captured by muni FE
Need an IV: Historic density mechanically uncorrelated with transport modelling

Strong first stage, small standard errors, insignificant correlation

Substantiates ATE vs. ATT story

FUNDAMENTALS II

effects on levels and trends

Proxies for fundamentals explain about 50% of the variation in fundamental productivity *levels*

First-nature geography explains a small fraction of variation in *productivity trends*

Mean reversion (conditional), specialization (workplace vs. residence), worker ability, and establishment productivity stronger predictors of *productivitiy trends*

	(1) Fundamental productivity (6)	(2) Fundamental productivity (6)	(3) Fundamental productivity (6)	(4) Prod. trend (6)	(5) Prod. trend (6)
Ln effective density, $t = 0$	0.007		0.009		0.032***
	(0.01)		(0.01)		(0.01)
Slope, mean		-0.004***	-0.003***	-0.002***	-0.000
		(0.00)	(0.00)	(0.00)	(0.00)
Slope, s.d.		0.004***	0.004**	0.002**	-0.000
		(0.00)	(0.00)	(0.00)	(0.00)
Elevation, mean		-0.000	-0.000	-0.000	-0.000
		(0.00)	(0.00)	(0.00)	(0.00)
Elevation, s.d.		0.000	0.000	0.000	0.000***
		(0.00)	(0.00)	(0.00)	(0.00)
Sun hours, mean		0.000***	0.000***	0.000**	0.000***
		(0.00)	(0.00)	(0.00)	(0.00)
Sun hours, s.d.		0.001	0.001	-0.000	0.000
		(0.00)	(0.00)	(0.00)	(0.00)
Temperature, mean		0.015***	0.010	0.014***	-0.007**
		(0.00)	(0.01)	(0.00)	(0.00)
Temperature, s.d.		0.050+	0.025	0.025	-0.042**
		(0.03)	(0.03)	(0.02)	(0.02)
Precipitation, mean		0.000***	0.000**	0.000**	-0.000*
		(0.00)	(0.00)	(0.00)	(0.00)
Precipitation, s.d.		-0.000	0.000	0.000*	0.000**
		(0.00)	(0.00)	(0.00)	(0.00)
Dist river $\in [0-20]$ km		0.011	0.009	0.016***	0.008*
		(0.01)	(0.01)	(0.00)	(0.00)
Dist river $\in]20-40]$ km		-0.013*	-0.012*	-0.007*	0.003
		(0.01)	(0.01)	(0.00)	(0.00)
Dist river $\in]40-60]$ km		-0.008	-0.006	-0.006*	-0.001
		(0.01)	(0.01)	(0.00)	(0.00)
Dist coast $\in [0-50]$ km		0.035***	0.038***	0.014***	0.016***
		(0.01)	(0.01)	(0.00)	(0.00)
Dist coast $\in]50-100]$ km		-0.020**	-0.007	-0.009**	0.015**
		(0.01)	(0.01)	(0.00)	(0.01)
Dist coast $\in]100-250]$ km		-0.005	0.002	-0.012***	0.004
		(0.01)	(0.01)	(0.00)	(0.00)
Dist coast $\in]250-500]$ km		0.003	0.006	-0.012***	-0.007**
		(0.01)	(0.01)	(0.00)	(0.00)
Ln transport potential			-0.006		-0.035***
			(0.01)		(0.01)
Highway (dummy)			0.018***		0.002+
			(0.00)		(0.00)
High-speed rail (dummy)			0.011**		0.006**
			(0.00)		(0.00)
Ln wage residual, model 6					-0.077***
					(0.01)
Ln wpl. emp. - ln res. emp.					0.031***
					(0.00)
Worker ability					0.025***
					(0.00)
Establishment productivity					0.012***
					(0.00)
First Stage: Pop. Density 1907	0.404**		0.186**		0.188**
	(0.019)		(0.014)		(0.014)
K-P rk LM statistic	90.108		39.319		38.377
K-P rk LM statistic (P-value)	0.000		0.000		0.000
R^2	0.450	0.495	0.508	0.0776	0.217
N	4,427	4,438	4,427	4,355	4297

CONCLUSION

summary

- **ATE estimate of density elasticity of labour productivity: 0.012**
  - **50% below consensus estimate, but still relevant!**
- **Policy implications**
  - **Productivity effects of density are quantitatively important**
    - Productivity effects within the range of travel time savings
    - Wider economic impacts relevant for transport appraisals
    - BUT: Need to use the ATE and not the mover ATT estimate
  - **High-skilled movers benefit more than low-skilled stayers**
    - Promoting effective density can be welfare enhancing
    - But there is an efficiency-equity tradeoff
      - Demand-driven increase in rents may harm the low-skilled

THANKS