Killer Cities and Industrious Cities: New Evidence on 250 Years of Urban Growth

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The views expressed in this paper are solely those of the authors and not necessarily those of the Bureau of Economic Analysis

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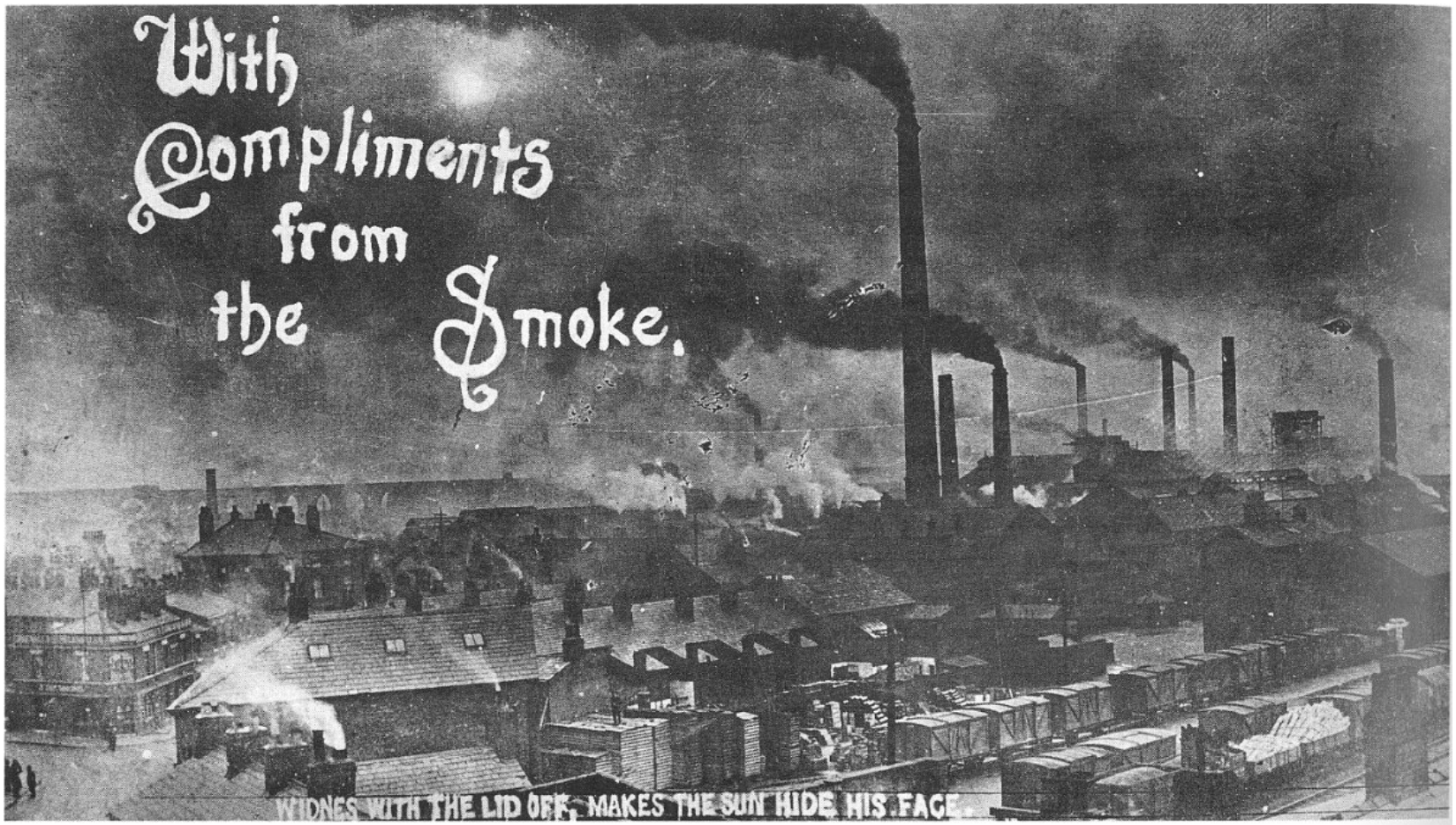
- Today's developing cities have annual growth rates of 2-4% (Jedwab, Christaensen, and Gindelsky 2015). At their peak, industrializing cities of the 19th century grew at only 2%
- Widely held belief of "urban penalty" during the industrial revolution: high mortality rates in cities which stifled their growth (Williamson 1990, 2002)
- Concurrent hypothesized effects of "industriousness" in urban cities: lower fertility rates (Seccombe 1993)
- Research Question: Is the standard "urban penalty" theory correct, and if so, what effect did it have on growth? What alternate factors affected the urban growth of industrial age cities?
- Contribution: Creation of a unique dataset to document novel stylized facts pertaining to
  - Killer cities
  - Agglomeration and congestion effects
  - Industrial Revolution

- Cities of Industrial Revolution (IR) period (predominantly 19th century) thought to be characterized by big increases in income and living standards, but also poor sanitation, environmental damage, and other consequences of congestion (Teitelbaum 1984)
- Literature studied cities such as Manchester, Liverpool etc. focused on two outcomes of IR:
  - Incomes/productivity $\uparrow \implies$ "industriousness" $\implies$ fertility $\downarrow$
  - Congestion effects/pollution $\implies$ mortality $\uparrow$
- Together, these effects constituted an "urban penalty" $\implies$ slow urban growth

Postcard from Widnes, UK

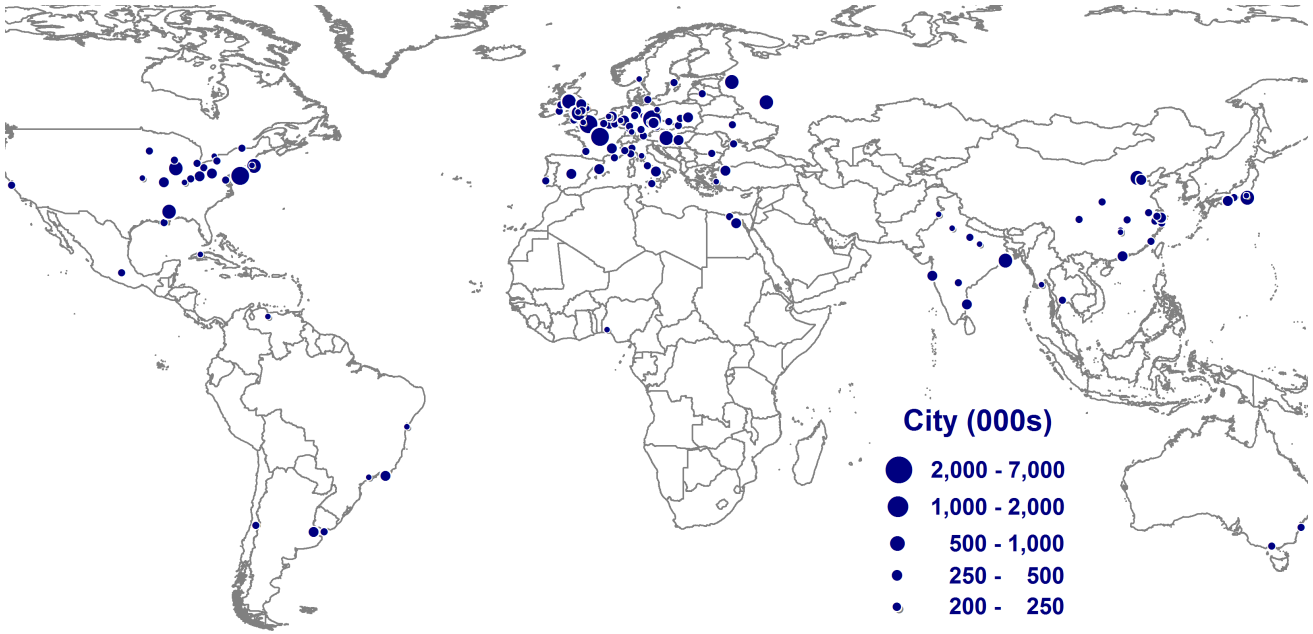


Baltimore Harbor - Summer 1897...

"The harbor cleaner hauled out 272 cartloads of material, with some surprising contents: '8 cartloads of dead alewives, 2 monkeys, 174 dogs, 238 cats, 1,722 rats, 257 chickens, 631 chunks of meat, 324 crabs, 1,096 pineapples, 36 bunches of fish, 12 sea turtles, 10 ducks, 3 large drum fish, 5 pigeons, 4 geese, 2 sparrows, 2 rock fish, 1 calf."' (Boone 2003)

- Construct a novel dataset to study the evolution of fertility (birth), mortality (death), and population (city size) in 1700-1950
- Study periods prior, during, and post IR
- Focus is on breadth **and** depth, instead of just one, or a single city/country case study (e.g., Ferrie and Troesken 2008, Klepp 1989, Duff 1972, etc.)
- First, examine effect of initial city size on crude rates of birth (CBR), death (CDR), and natural increase (CRNI)
- Next, examine effects of initial city size and natural increase on annualized city growth
- Find that cities like Manchester & Liverpool are counterexamples (anomalies) - though high, mortality was diminishing prior to IR and slower growth was due to its initial levels of "urban penalty", not effects of IR

- City-level decadal data for 35 countries 1700-1950: 3,692 obs
  - Crude Death Rate: 1,007 obs (27.3% of sample)
  - Crude Birth Rate: 865 obs (23.4% of sample)
  - Crude Rate of Natural Increase (Both Rates): 825 obs (22.3%)
- Focus on the largest cities at the turn of the 20th century (142 cities with a population $\geq$200,000) (Chandler 1987)
- Largest data set ever constructed on the demographic history of these cities $\Longrightarrow$ many new insights
- Data is highly representative of world's urban pop from 1880 onwards. For prior period, using all available information, capture 10-50%

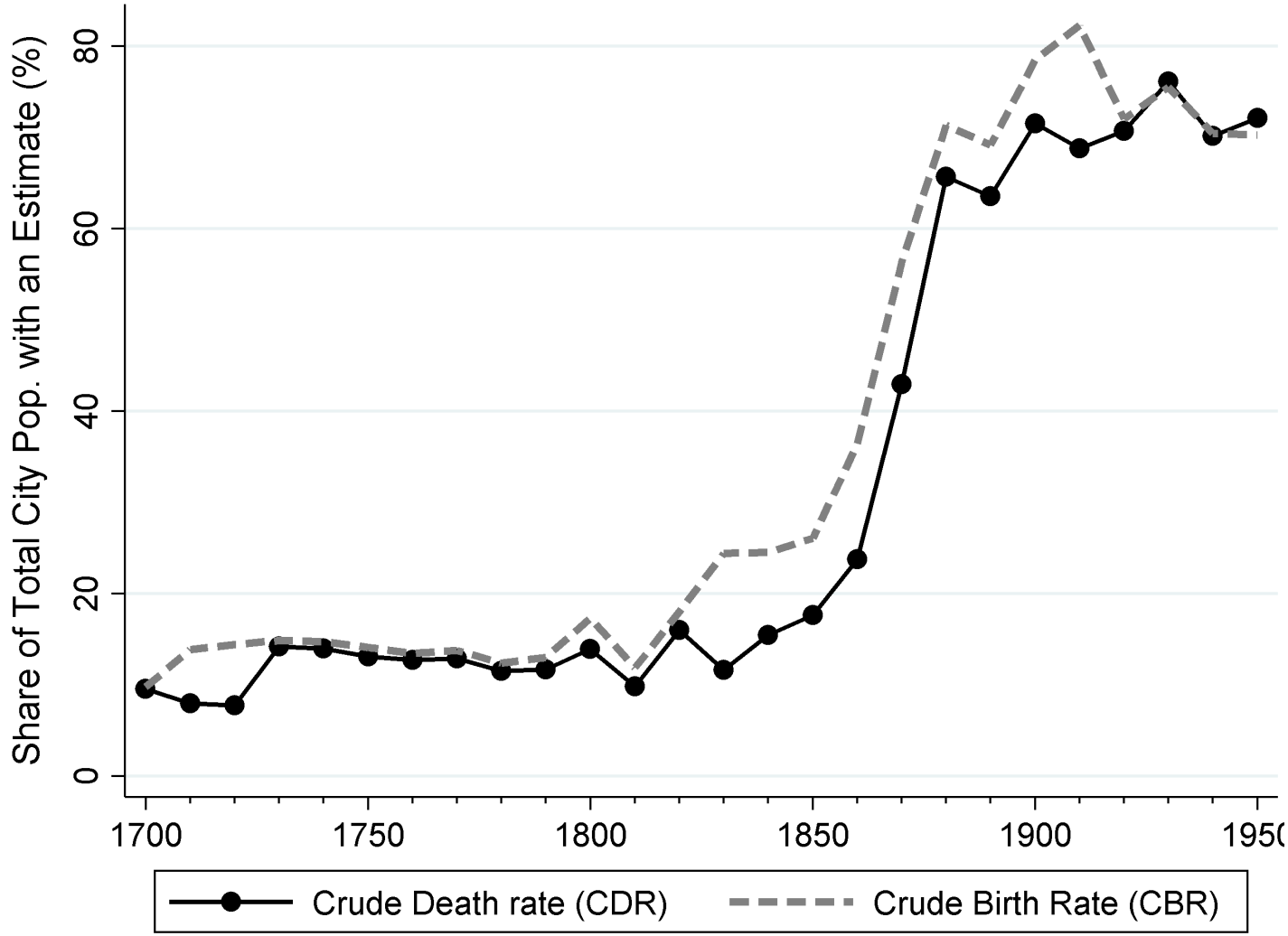


Notes: This figure shows 142 cities above 200,000 inhabitants in 1900 according to (Chandler 1987). London is the largest city with 6,480,000 inh., and Foshan is the smallest city with 200,000 inh.

- >300 sources used
  - 1/3 scholar works (books, monographs, peer-reviewed articles, etc.)
  - 1/2 publications by statistical offices (censuses, statistical abstracts, public health reports)
  - Remaining 1/6 independent reports, news articles, other studies
- Some population data linearly interpolated
- Incomplete, but largest existing dataset of its kind to our knowledge

- Very few obs before 1800 (approx. 10% of sample, then 20% by 1850) - Existing ones are for Europe
- Generally more CDR than CBR, especially in 19th century
- Much better coverage/quality starting in 1850 + broader range of countries
- When pop-weighted, slightly higher percentage of countries $\Longrightarrow$ more data for bigger cities

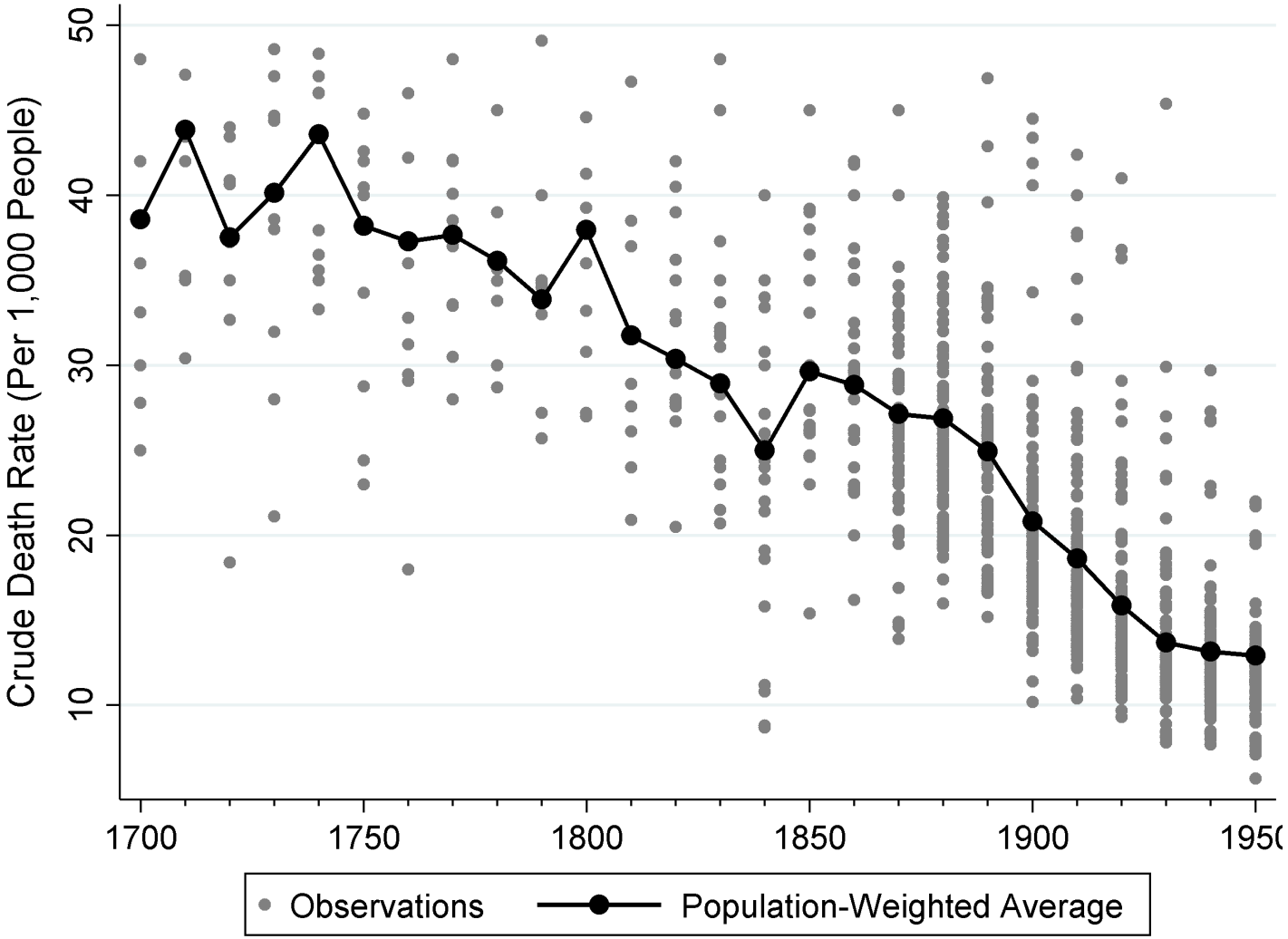
SHARE OF OBS WITH AN ESTIMATE OF THE DEMOGRAPHIC RATES: POP WEIGHTED



Notes: The panel describes the same patterns when weighting the observations by their population in each decade, which allows us to show the share of the total city population in each decade with an estimate for the crude birth rate and an estimate for the crude death rate (per 1,000 people).

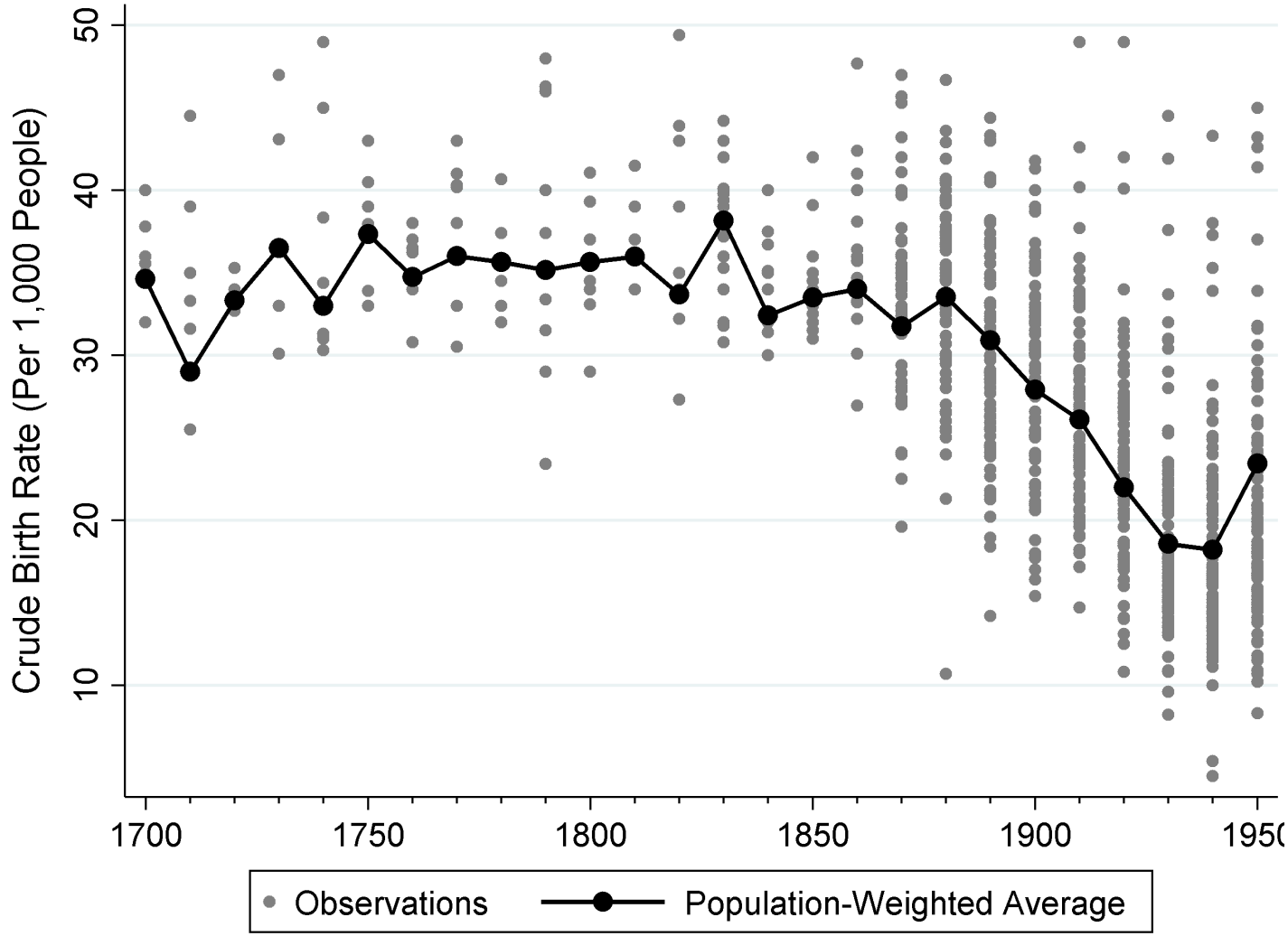
- Death rates high at 40, prior to IR, falling steadily in 19th century
- Birth rates remained high at around 35 until mid-19th century, after which they began to decline
- Until 19th century, death rates were as high or higher than birth rates, leading to negative natural increase. Both rates began falling in 19th century, but CDR fell faster
- CRNI remained low (<10), but this still means cities grew naturally at 0.5-1% per year
- A lot of variation in data

AGGREGATE EVOLUTION OF CRUDE DEATH RATES



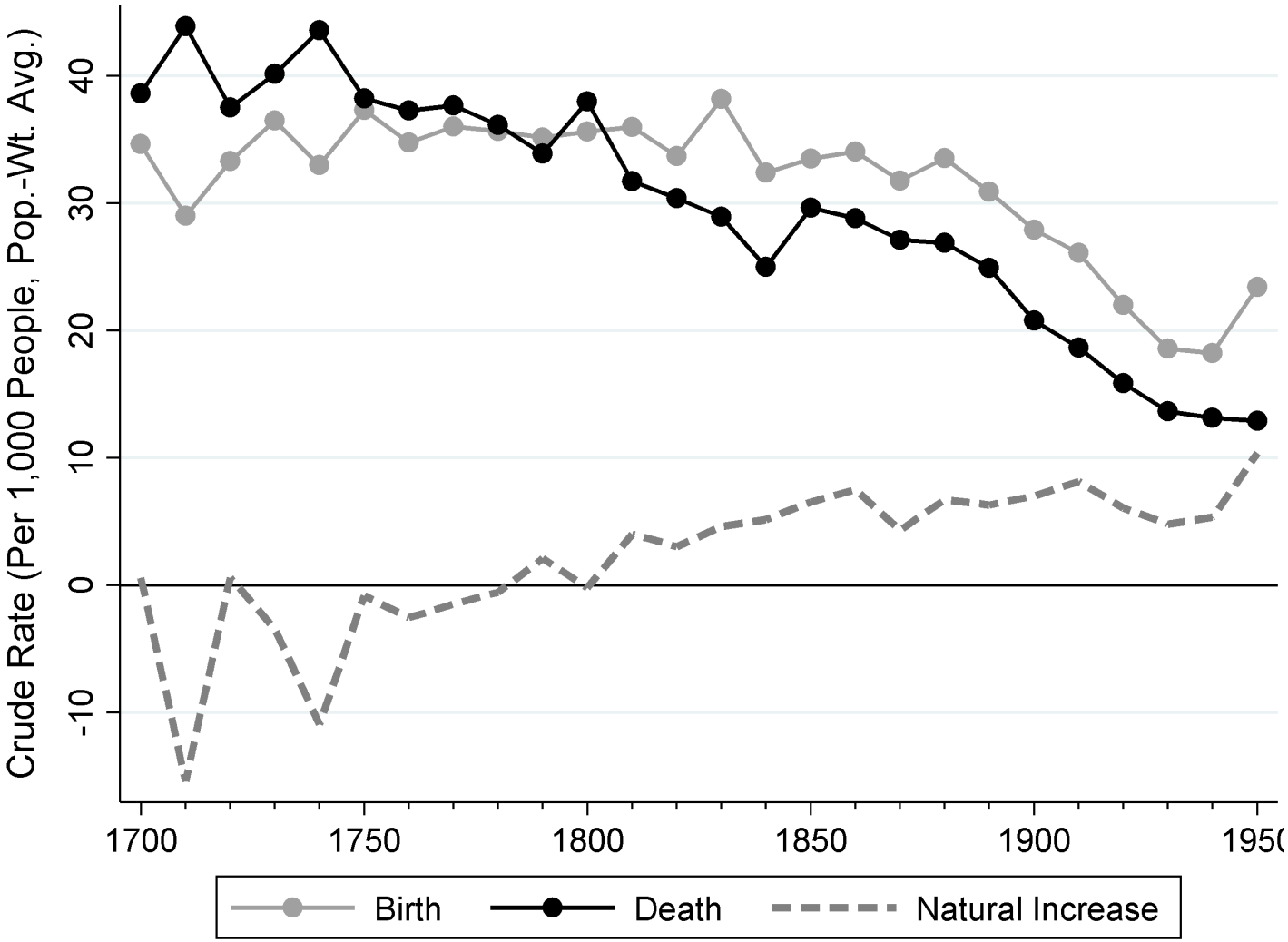
Notes: The figure shows the crude death rate (per 1,000 people) for 1,007 city-decade observations. We do not show the outlying observations with a death rate above 50. The figure also shows the average death rate for each decade when weighting each city-decade observation by its population in that decade.

AGGREGATE EVOLUTION OF CRUDE BIRTH RATES



Notes: The figure shows the crude birth rate (per 1,000 people) for 865 city-decade observations. We do not show the outlying observations with a birth rate above 50. The figure also shows the average birth rate for each decade when weighting each city-decade observation by its population in that decade.

AGGREGATE EVOLUTION OF CRUDE RATE OF NATURAL INCREASE



Notes: The figure shows the average crude rates of birth, death and natural increase (per 1,000 people) when weighting each city-decade observation by its population in that decade (data for 1,007, 865 and 825 city-decade observations respectively).

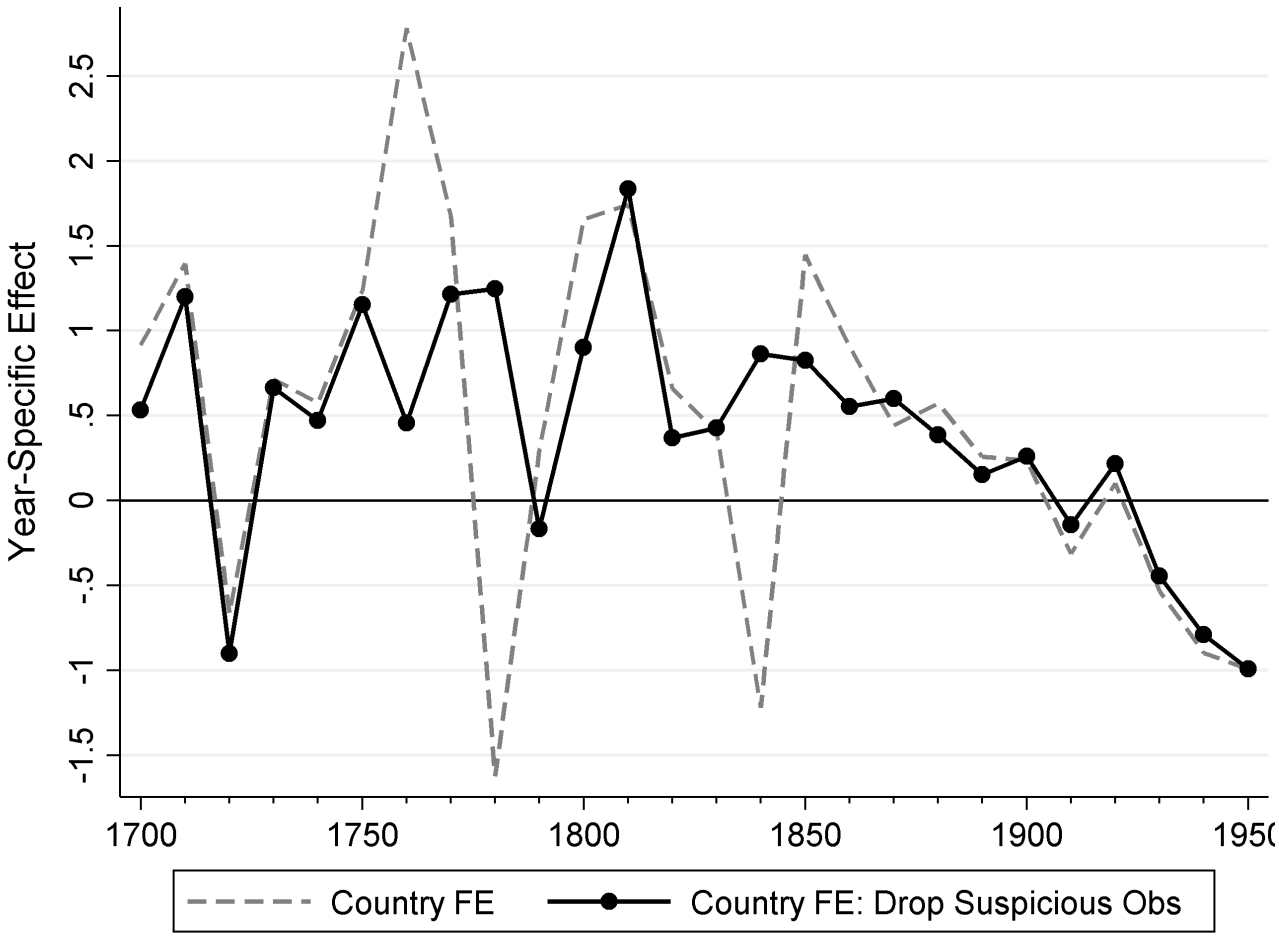
- Effect of citysize on crude rates of death, birth, and natural increase
- Base specification for Tables:
  $Demrate_{i,c,t} = \alpha + LogCitySize_{i,c,t} + \epsilon_{i,c,t}$
- Base specification for Graphs:
  $Demrate_{i,c,t} = \alpha + LogCitySize_{i,c,t} + \gamma_t LogCitySize_{i,c,t} + \epsilon_{i,c,t}$
- Additional controls (vary by column)
  - Year FE: δ_t
  - Country Fixed Effects: θ_c
  - City Fixed Effects: κ_i
  - Country-Year Fixed Effects $\lambda_{c,t}$

Table 1: Effect of Log(City Pop) (Inh.) on City Crude Death Rate (Per 1,000)

	(1)	(2)	(3)	(4)	(5)
	Panel A: All Observations				
Ln(City Size)	-3.59***	0.68*	0.27	0.39	0.57
	[0.46]	[0.38]	[0.27]	[0.80]	[1.33]
Observations	1,007	1,007	1,007	1,007	1,007
	Panel B: No Suspicious Observations				
Ln(City Size)	-3.39***	0.63*	0.21	-0.12	0.27
	[0.45]	[0.34]	[0.25]	[0.77]	[1.27]
Observations	935	935	935	935	935
Year FE	No	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	No	No
City FE	No	No	No	Yes	Yes
Country-Year FE	No	No	No	No	Yes

Notes: Robust standard errors clustered at the city level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 1: CDR (Country FE)



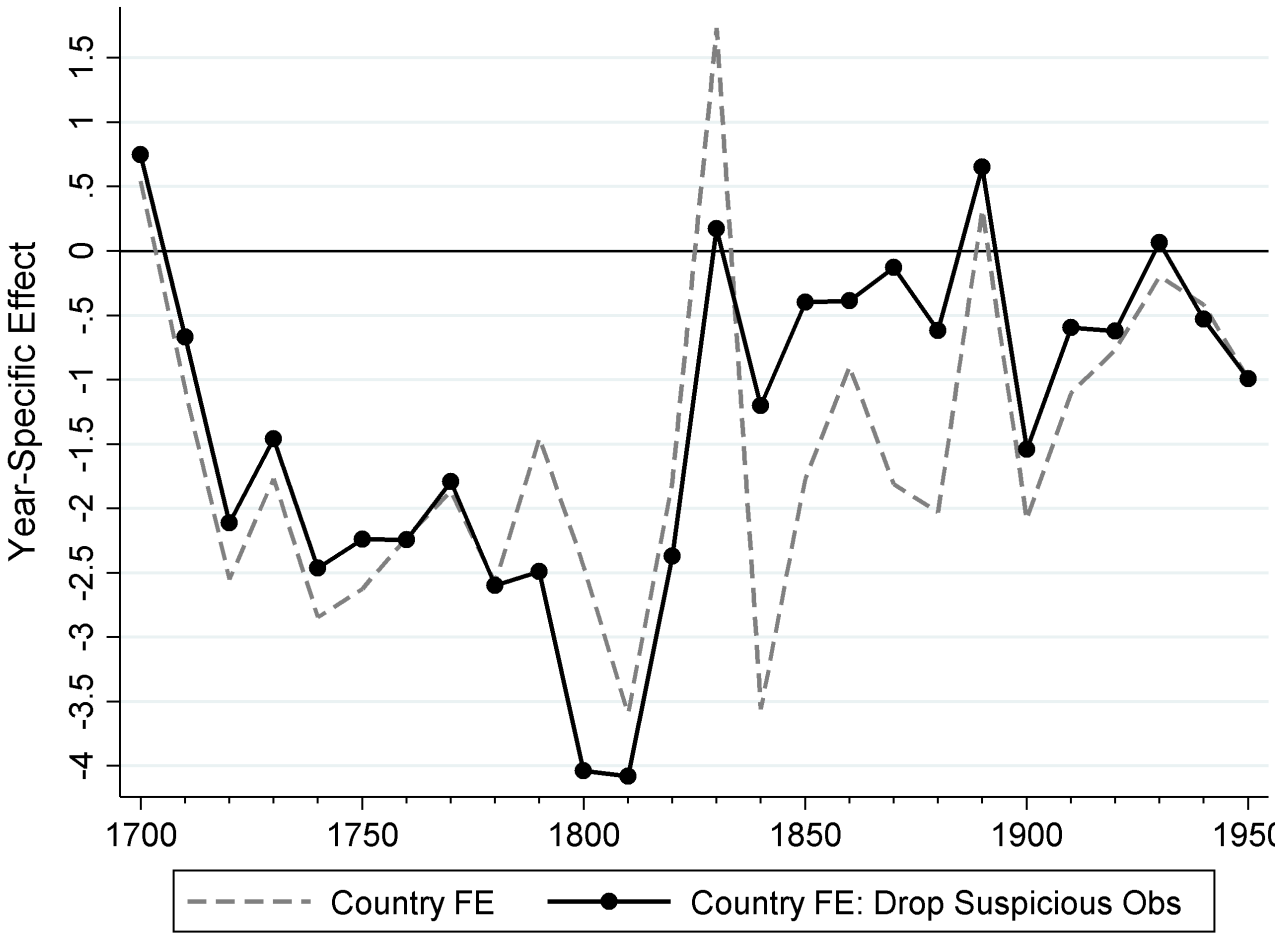
Notes: This figure shows the effect of log city population (inh.) on the city crude death rate (per 1,000 people), conditional on year fixed effects, as well as country fixed effects (N = 1,007 when using all observations).

Table 2: Effect of Log(City Pop) (Inh.) on City Crude Birth Rate (Per 1,000)

	(1)	(2)	(3)	(4)	(5)
	Panel A: All Observations				
Ln(City Size)	-4.03***	-1.18**	-1.24***	-1.55**	-1.94
	[0.53]	[0.54]	[0.32]	[0.59]	[1.34]
Observations	865	865	865	865	865
	Panel B: No Suspicious Observations				
Ln(City Size)	-3.94***	-0.92*	-0.92***	-1.80***	-2.43*
	[0.55]	[0.55]	[0.29]	[0.57]	[1.38]
Observations	807	807	807	807	807
Year FE	No	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	No	No
City FE	No	No	No	Yes	Yes
Country-Year FE	No	No	No	No	Yes

Notes: Robust standard errors clustered at the city level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 2: CBR (Country FE)



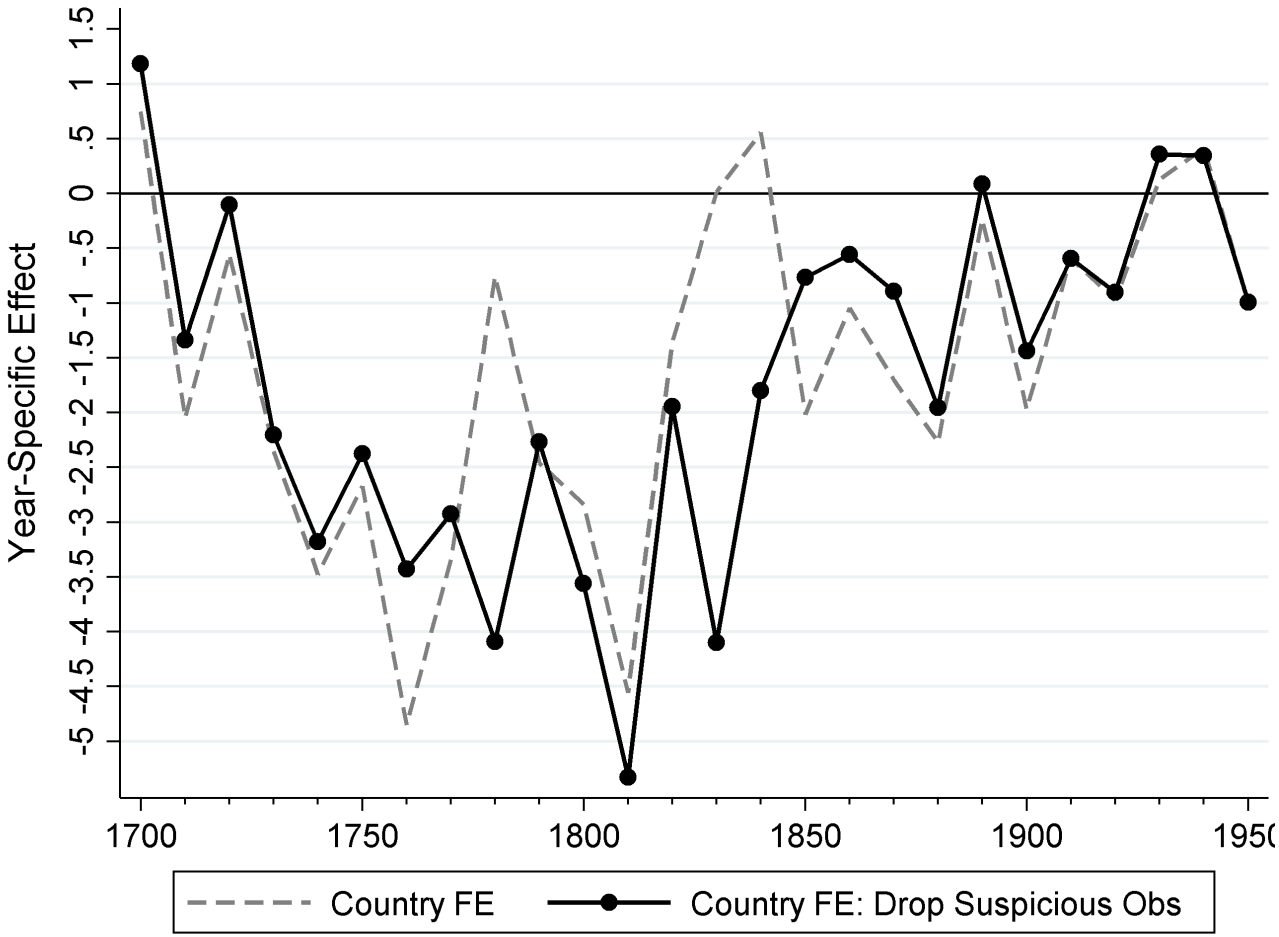
Notes: This figure shows the effect of log city population (inh.) on the city crude birth rate (per 1,000 people), conditional on year fixed effects, as well as country fixed effects (N = 865 when using all observations).

Table 3: Effect of Log(City Pop) (Inh.) on City Crude Ratio of Natural Increase (Per 1,000)

	(1)	(2)	(3)	(4)	(5)
	Panel A: All Observations				
Ln(City Size)	-0.30	-1.48***	-1.21***	-1.93*	-1.88
	[0.61]	[0.51]	[0.40]	[1.13]	[1.93]
Observations	825	825	825	825	825
	Panel B: No Suspicious Observations				
Ln(City Size)	-0.30	-1.48***	-1.21***	-1.93*	-1.88
	[0.61]	[0.51]	[0.40]	[1.13]	[1.93]
Observations	825	825	825	825	825
Year FE	No	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	No	No
City FE	No	No	No	Yes	Yes
Country-Year FE	No	No	No	No	Yes

Notes: Robust standard errors clustered at the city level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 3: CRNI (Country FE)



Notes: This figure shows the effect of log city population (inh.) on the city crude rate of natural increase (per 1,000 people), conditional on year fixed effects, as well as country fixed effects (N = 825 when using all observations).

- City size is positively correlated with mortality rates, though this effect is largely insig.
- City size is negatively correlated with birth rates, but effect diminishes after 1850
- From CRNI analysis, larger cities have lower rates of natural increase, but...
- Urban penalty effect is initially present, diminishes after 1850 (i.e., during IR), instead of increasing and disappears in 20th century
- Note: caution is necessary when interpreting 18th century results due to obs counts and quality

- Effect of natural increase and initial city size on annualized city growth
- Base specifications for Tables:
  $Growth_{i,c,t} = \alpha + \phi Demrate/10_{i,c,t} + \epsilon_{i,c,t}$
  $Growth_{i,c,t} = \alpha + \gamma LogCitySize_{i,c,t} + \epsilon_{i,c,t}$
  $Growth_{i,c,t} = \alpha + \gamma LogCitySize_{i,c,t} + \phi Demrate/10_{i,c,t} + \epsilon_{i,c,t}$
- Base specifications for Graphs:
  $Growth_{i,c,t} = \alpha + \phi Demrate/10_{i,c,t} + \psi_t Demrate/10_{i,c,t} + \epsilon_{i,c,t}$
  $Growth_{i,c,t} = \alpha + \phi Demrate/10_{i,c,t} + \psi_t Demrate/10_{i,c,t} +$
  $\gamma LogCitySize_{i,c,t} + \rho_t LogCitySize_{i,c,t} + \epsilon_{i,c,t}$
- Table and graph structure as before

Table 4: Effect of City CRNI (Per 100) on Annualized City Growth (%)

	(1)	(2)	(3)	(4)	(5)
Panel A: All Observations					
CRNI	0.73***	0.76***	0.71***	0.65***	0.61**
	[0.12]	[0.11]	[0.13]	[0.15]	[0.28]
Observations	825	825	825	825	825
Panel B: No Suspicious Observations					
CRNI	0.89***	0.93***	0.87***	0.86***	0.28
	[0.16]	[0.15]	[0.18]	[0.22]	[0.28]
Observations	731	731	731	731	731
Panel C: Controlling for Initial Log City Population (Inh.)					
CRNI	0.67***	0.64***	0.61***	0.41**	0.26
	[0.15]	[0.12]	[0.15]	[0.24]	[0.20]
Observations	825	825	825	825	825
Panel D: No Suspicious Observations					
CRNI	0.82***	0.83***	0.79***	0.66**	0.05
	[0.19]	[0.16]	[0.19]	[0.26]	[0.23]
Observations	731	731	731	731	731
Year FE	No	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	No	No
City FE	No	No	No	Yes	Yes
Country-Year FE	No	No	No	No	Yes

Notes: Robust standard errors clustered at the city level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Effect of City CBR & CDR (per 100) on Annualized City Growth (%)

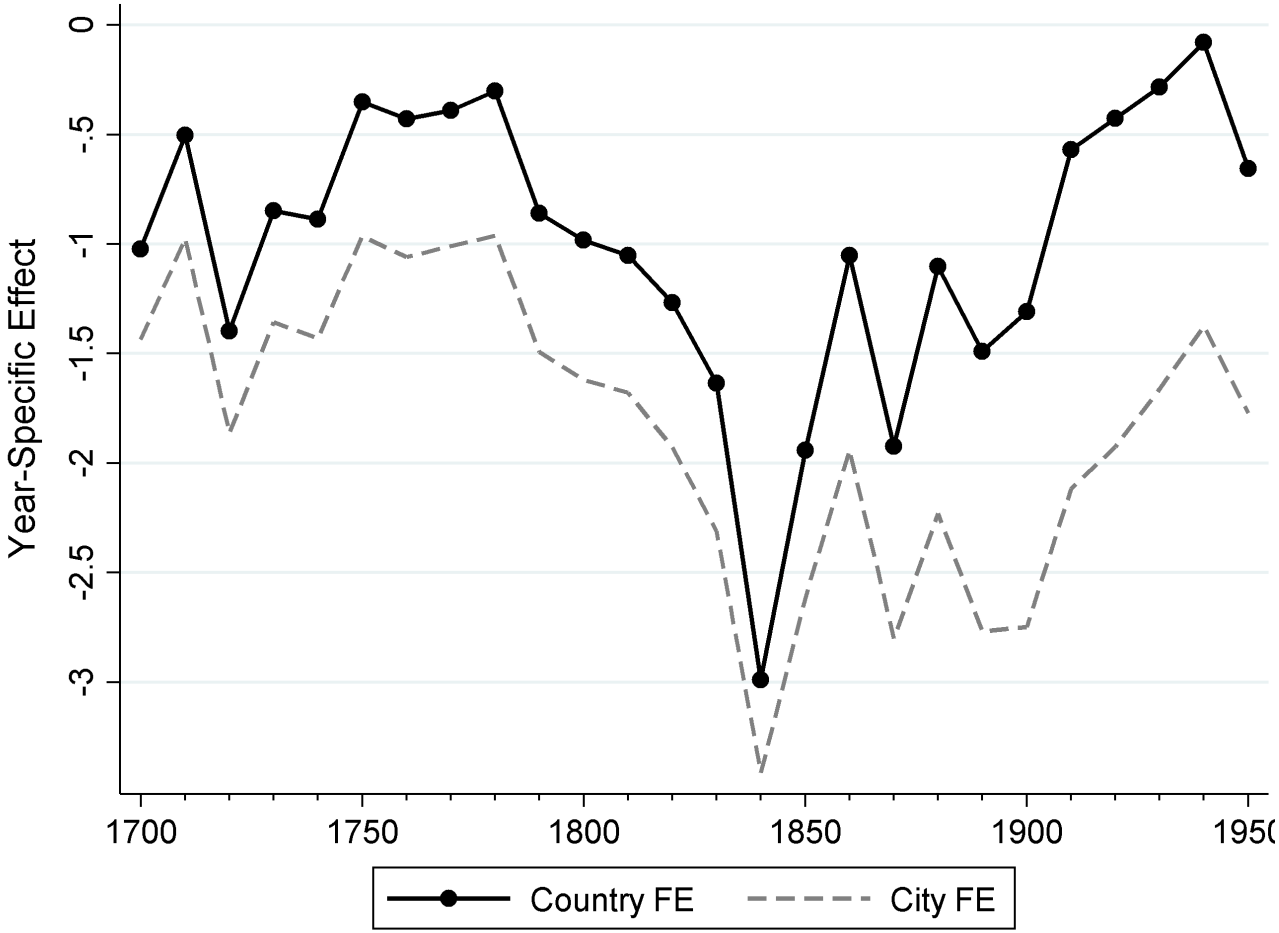
	(1)	(2)	(3)	(4)	(5)
Panel A: All Observations					
Crude Birth Rate	0.97***	0.95***	0.78***	0.80***	0.61**
	[0.14]	[0.13]	[0.15]	[0.19]	[0.28]
Crude Death Rate	-0.46***	-0.46***	-0.62***	-0.49**	-0.62
	[0.17]	[0.14]	[0.19]	[0.21]	[0.47]
Observations	825	825	825	825	825
Panel B: No Suspicious Observations					
Crude Birth Rate	1.07***	1.14***	0.89***	0.91***	0.37
	[0.19]	[0.15]	[0.19]	[0.23]	[0.35]
Crude Death Rate	-0.56***	-0.49**	-0.84***	-0.79**	-0.12
	[0.21]	[0.19]	[0.28]	[0.32]	[0.42]
Observations	731	731	731	731	731
Panel C: Controlling for Initial Log City Population (Inh.)					
Crude Birth Rate	0.83***	0.82***	0.64***	0.46**	0.22
	[0.16]	[0.13]	[0.16]	[0.20]	[0.23]
Crude Death Rate	-0.53***	-0.37***	-0.57***	-0.36	-0.34
	[0.17]	[0.14]	[0.20]	[0.24]	[0.30]
Observations	825	825	825	825	825
Panel D: No Suspicious Observations					
Crude Birth Rate	0.97***	1.04***	0.78***	0.57**	0.04
	[0.20]	[0.15]	[0.19]	[0.25]	[0.30]
Crude Death Rate	-0.62***	-0.41**	-0.80***	-0.79**	-0.07
	[0.20]	[0.19]	[0.28]	[0.33]	[0.30]
Observations	731	731	731	731	731
Year FE	No	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	No	No
City FE	No	No	No	Yes	Yes
Country-Year FE	No	No	No	No	Yes

Table 6: Effect of Initial Log(City Pop) (Per 100) on Annualized City Growth (%)

	(1)	(2)	(3)	(4)	(5)
Panel A: All Observations					
Ln(City Size)	-0.58***	-1.04***	-1.04***	-1.67***	-2.19***
	[0.09]	[0.13]	[0.15]	[0.26]	[0.40]
Observations	3,305	3,305	3,305	3,305	3,305
Panel B: Controlling for the Crude Rate of Natural Increase (Per 100 People)					
Ln(City Size)	-0.38***	-0.37***	-0.35***	-1.53***	-3.72***
	[0.08]	[0.11]	[0.13]	[0.30]	[0.62]
Observations	825	825	825	825	825
Year FE	No	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	No	No
City FE	No	No	No	Yes	Yes
Country-Year FE	No	No	No	No	Yes

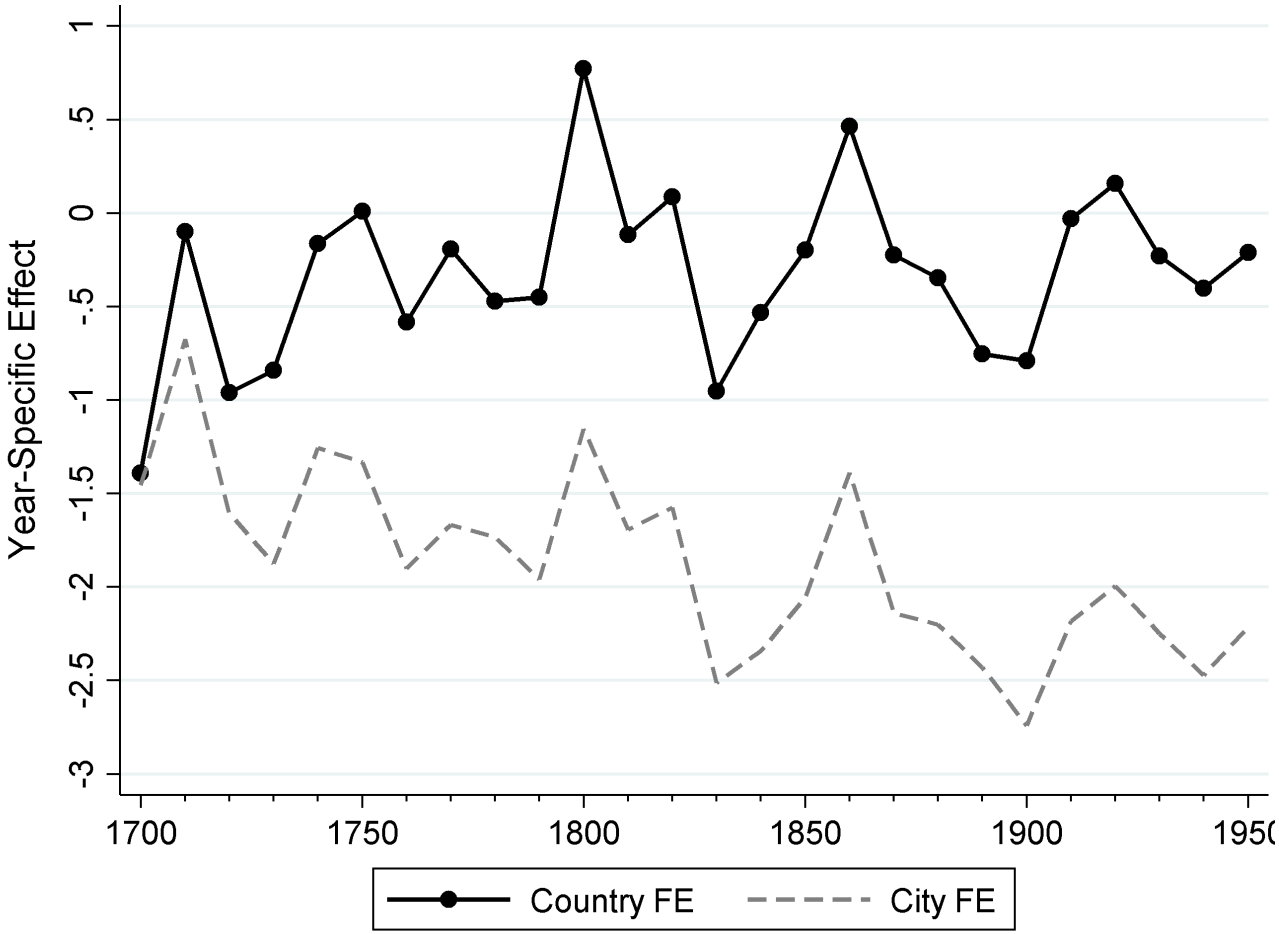
Notes: Robust standard errors clustered at the city level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 4: Effect of City Size



Notes: This figure shows the effect of initial log city population (inh.) on annualized city population growth (%), conditional on year fixed effects and country fixed effects or city fixed effects (N = 3,305 when using all observations).

Figure 5: Effect of City Size, Conditional on CRNI



Notes: This figure shows the effect of initial log city population (inh.) on annualized city population growth (%), conditional on year fixed effects and country fixed effects or city fixed effects, as well as city crude rate of natural increase interacted with year fixed effects (N = 825 when using all observations).

- Natural increase has a positive and significant effect on annualized growth, though it's <1, possibly due to
  - Measurement error biases toward 0
  - Family may move (esp. within country migration) - restricted inter-country mobility moves effect closer to 1
- This effect is driven mainly by the birth rate and is attenuated when controlling for initial pop (since it also affects CRNI)

- Initial city size has a negative and significant effect on annualized growth, indicating convergence, but which has changed over time
  - Initially urban penalty is large, possibly increasing $\Longrightarrow$ bigger cities grew even slower 1800-1850
  - Post-1850, penalty disappears $\Longrightarrow$ bigger cities are less constrained
- Accounting for CRNI, no pattern in effect of initial city size on growth within countries $\Longrightarrow$ natural increase primarily drives relationship between initial city size and growth, rather than other factors
- Conditional convergence when looking within-city: city grows slower due to stronger effects of agglomeration and congestion

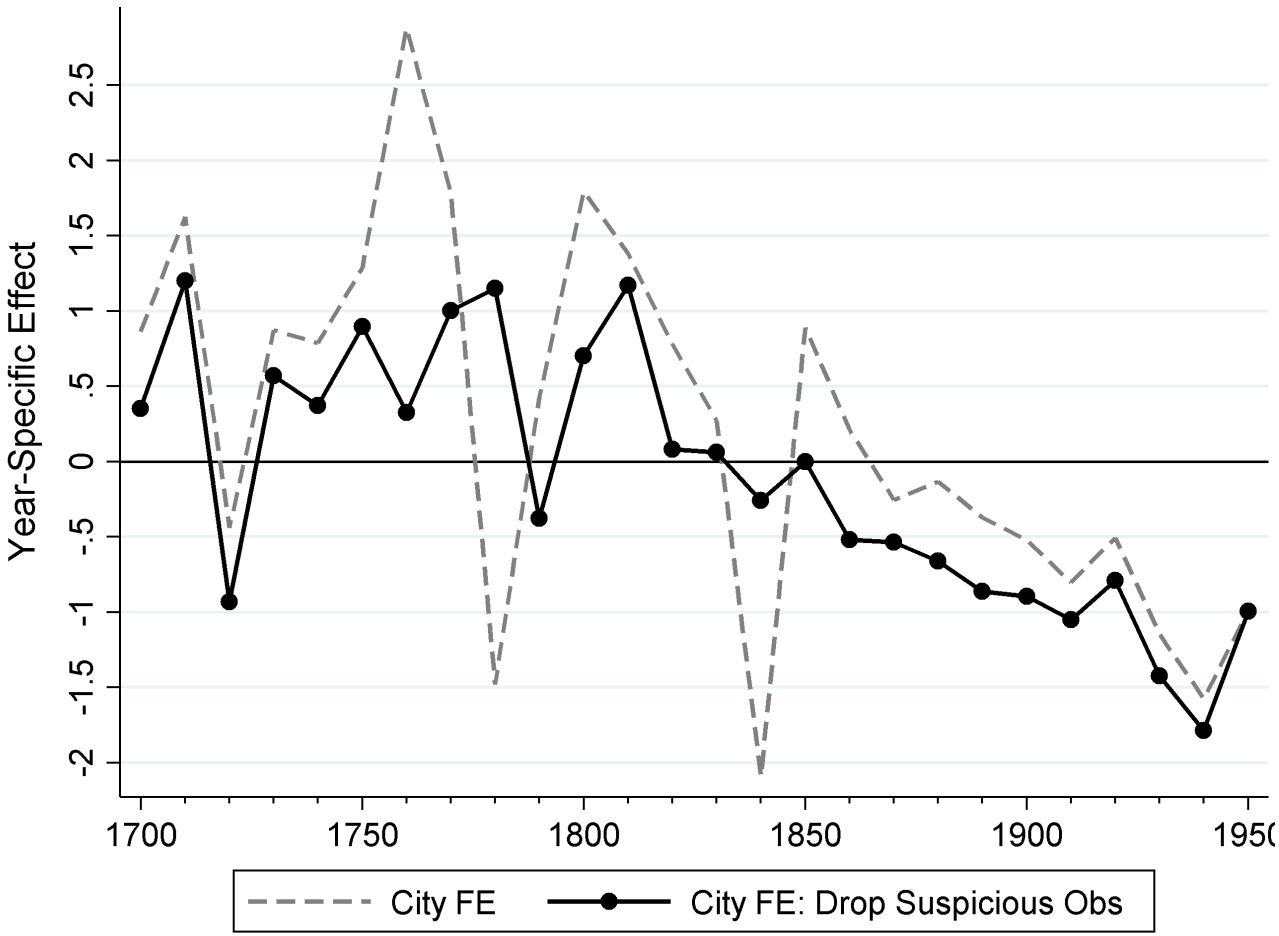
- Regression analysis reflects bigger countries in the latter half
- Measurement error may not be classical
- Biases from selection: which data is available, cities entering/exiting
- Effects from reductions in infant mortality/total fertility rate
- Robustness checks
  - Fertility/mortality rates
  - Unweighted averages
  - Dropping outliers/suspicious obs
  - Data for whole urban sector rather than individual cities

- **Myth:** "Urban penalty" of slow growth driven by high mortality/low fertility from Industrial Revolution
  Finding: Mortality and fertility had started decline significantly beforehand: initial levels caused slow growth (i.e. pre-1850)
- City size had bigger (and significant) effects on reducing birth rate than increasing death rate (small and insig.)
- Natural increase has positive and sig effect on annualized growth
- Within-country convergence driven by natural increase, rather than other factors (bigger cities grew slower)
- Within-city conditional convergence (agglomeration and congestion)
- Caution interpreting 18th century results

- Examine relationship between initial city size and migration
- Robustness check with 20yrs (rather than 10)
- How to reduce bias from measurement error? composition? selection?

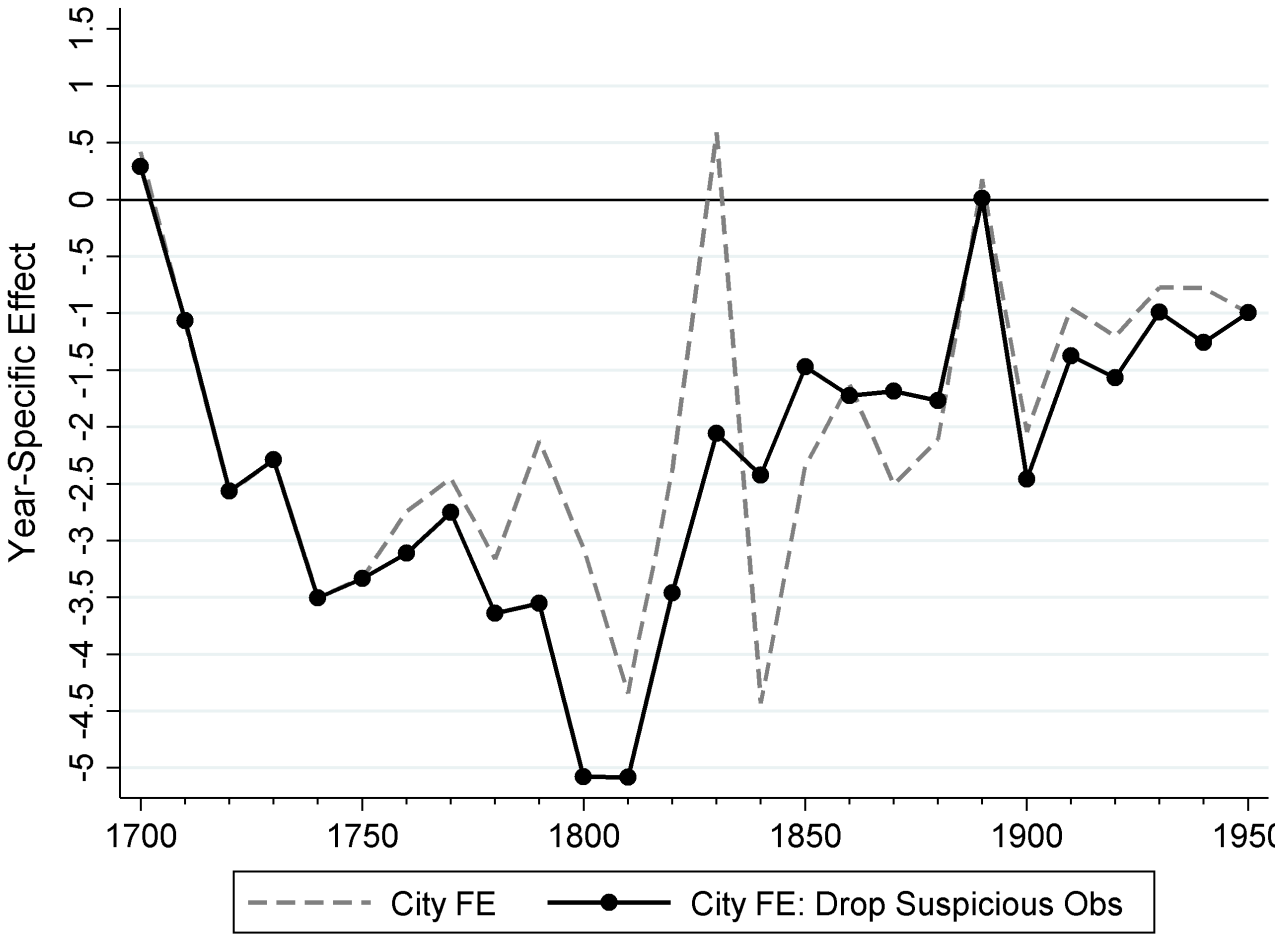
Thank you!

Figure 6: CDR (City FE)



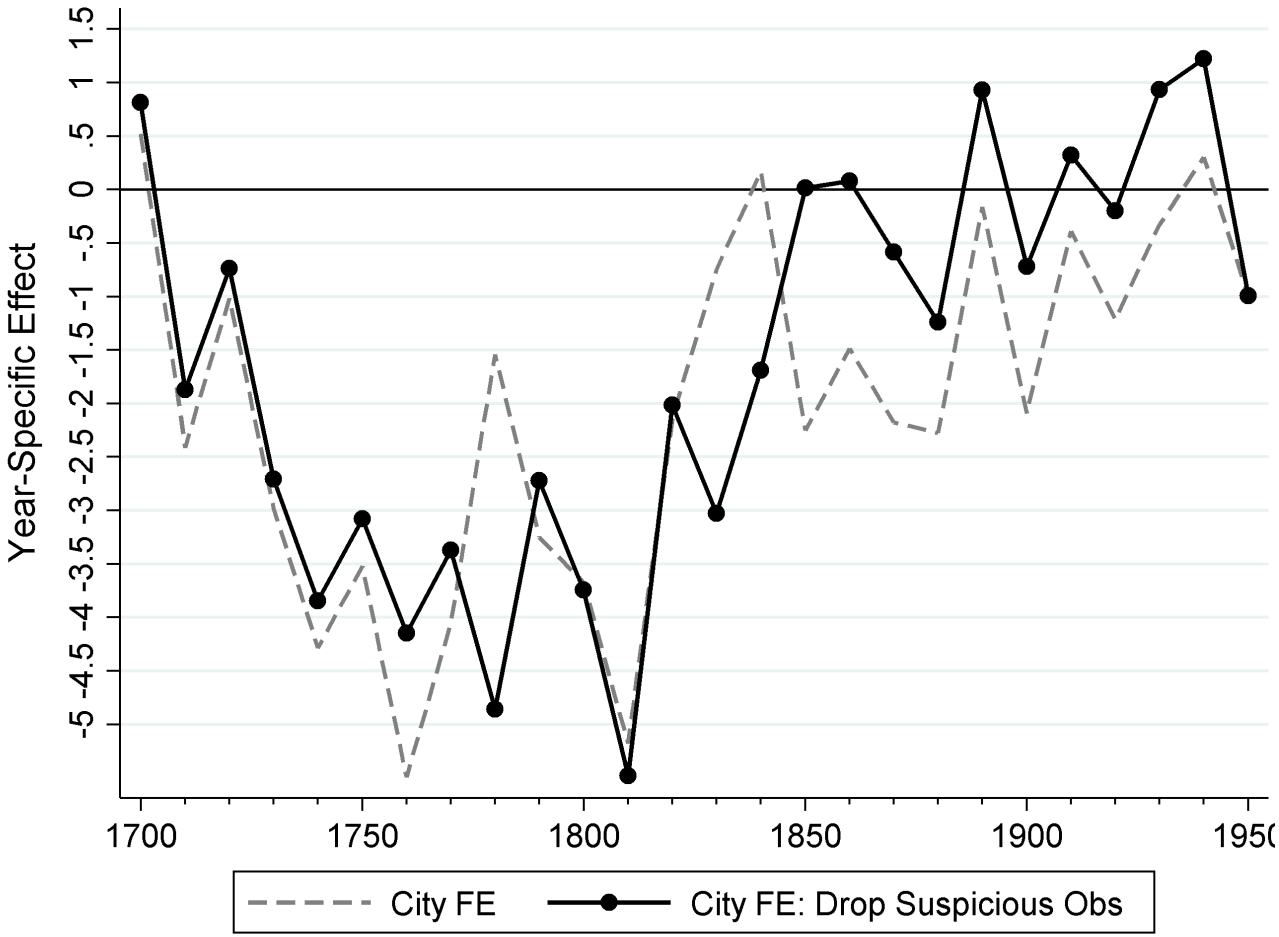
Notes: This figure shows the effect of log city population (inh.) on the city crude death rate (per 1,000 people), conditional on year fixed effects, as well as city fixed effects, (N = 935 when dropping suspicious observations).

Figure 7: CBR (City FE)



Notes: This figure shows the effect of log city population (inh.) on the city crude birth rate (per 1,000 people), conditional on year fixed effects, as well as city fixed effects, (N = 865 when dropping suspicious observations).

Figure 8: CRNI (City FE)



Notes: This figure shows the effect of log city population (inh.) on the city crude rate of natural increase (per 1,000 people), conditional on year fixed effects, as well as city fixed effects, (N = 731 when dropping suspicious observations).