Immigration and Invention: Evidence from the Quota Acts

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Scarce Factors of Production and Technological Change

- Sir John Hicks, *The Theory of Wages*, 1932: "a change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind – directed to economizing the use of a factor which has become relatively expensive."

Scarce Factors of Production and Technological Change

- In 1962, Sir John Habakkuk's famous hypothesis applied Hicks' argument to the first Industrial Revolution:
  - Labor scarcity in the United States during the first half of the nineteenth century lead to the development of better labor-saving devices in the United States than in England, where labor was plentiful (Habakkuk, 1962).

Scarce Factors of Production and Technological Change

- Because inventions are often designed to economize on labor, it is intuitive that making labor less plentiful should increase the incentive to invent.
- Consider, for example, the famous inventions of America's Second Industrial Revolution in the late nineteenth and early twentieth centuries:
  - automated assembly lines
  - new consumer goods designed to be mass produced cheaply, such as Ford's automobile, or cheap and long-lasting electric light bulbs.
- These new inventions were at least as high quality as previous products, but were made with much less labor.
  - person hours to produce a usable automobile declined by 80 percent
- Since these inventions allowed the same quality good to be produced for much less labor, the incentive to invent these inventions should have increased when labor was scarce.

Scarce Factors of Production and Technological Change

- But, in fact, the usefulness of these inventions was not unrelated to scale.
- Consider the cluster of inventions around the automobile, for example:
  - Henry Ford's new automobile factory was the largest production facility in the world.
  - 3,000 parts needed to be combined through 7,882 tasks.
  - Given so many unique tasks, in order to take advantage of the full benefits of the division of labor, the new assembly line required 14,000 employees.

Ford's new Highland Park Factory, 2015

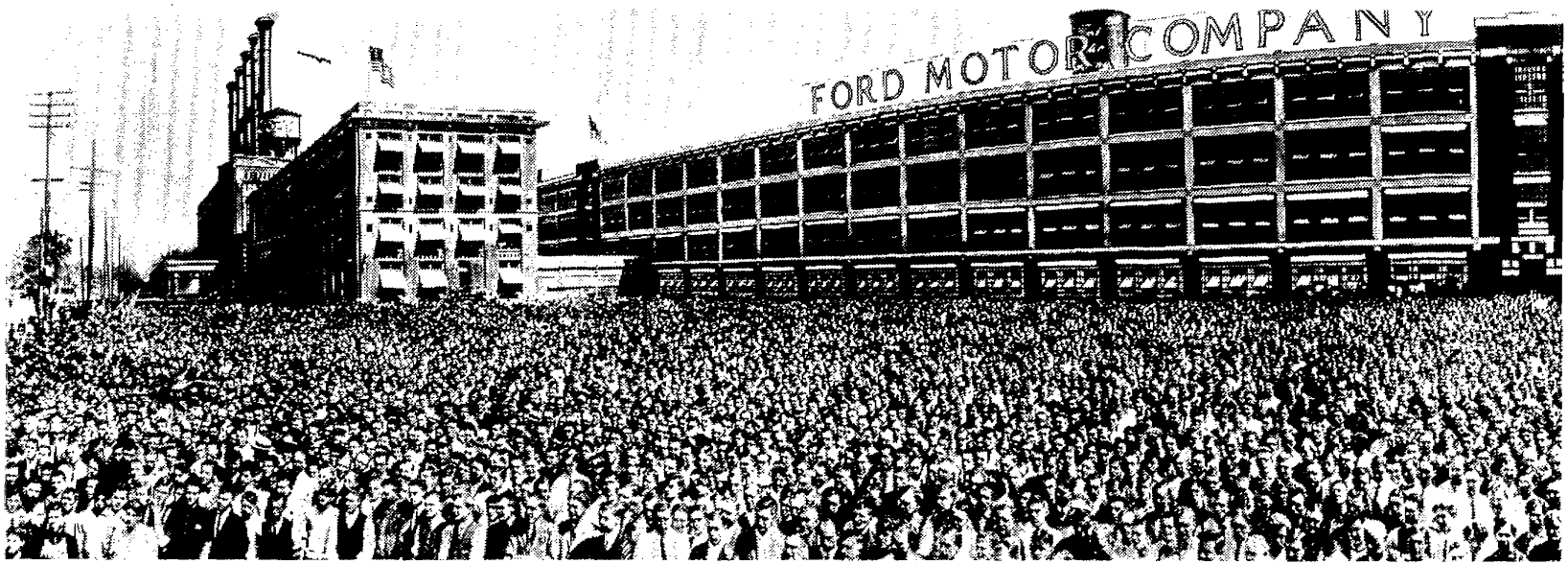

FIGURE 0.2. Ford Motor Company, Highland Park Factory Employees, 1915. (Henry Ford Museum, The Edison Institute. Neg. No. 833-700.)

Scarce Factors of Production and Technological Change

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- Consider the cluster of inventions around the automobile, for example:
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  - 3,000 parts needed to be combined through 7,882 tasks.
  - Given so many unique tasks, in order to take advantage of the full benefits of the division of labor, the new assembly line required 14,000 employees.
- Thus, it is possible that, in general equilibrium, it wouldn't have been worthwhile to invent the inventions characteristic of America's second industrial revolution without plentiful labor supply.

Scarce Factors of Production and Technological Change

- Indeed, (Acemoglu, 2010) shows that in general equilibrium, contrary to Hicks and Habakkuk, plentiful labor supply will encourage invention in the context of any of the canonical macroeconomic models:
  - "In most models used in the macroeconomics and growth literatures, . . . labor scarcity will discourage rather than induce technological change."
- Outside the context of canonical macroeconomic models, there exist other models in which labor scarcity does encourage technological change in general equilibrium:
  - Chambernowne (1963), Zeira (1998, 2006), and Hellwig and Irmen (2001).
- Acemoglu: "Although technology tends to be strongly labor complementary (rather than labor saving) in many commonly used models, this does not imply that it is so in reality. Whether labor scarcity and high wages may induce innovation and technology adoption in practice is thus an open empirical question. . ."

Scarce Factors of Production and Technological Change

- This long-running debate is not only theoretical; it intersects with a policy question of perennial concern: how will mass migration affect the innovativeness of a society, and thus long-term economic growth?
- On the one hand, under the Hicks/Habakkuk hypothesis mass migration will reduce labor scarcity and thereby reduce the incentive to invent.
- On the other hand, under the Acemoglu general equilibrium results, mass migration will reduce labor scarcity and thereby increase the incentive to invent.
- In spite of the importance of this question to both economic theory and policy, the causal empirical literature relating immigration to innovation has not addressed it.

Scarce Factors of Production and Technological Change

- How can we use empirical evidence to address this debate?

How to test whether the relationship is positive or negative

- We need an event which changed immigration rates
- We need the change in immigration to last an extended time
- We need the change in immigration to vary across locations
- We need many such locations, for sufficient statistical power
- We need there to be innovative people or firms in each of these locations
- We need to be able to measure innovation outcomes of people and firms located in these locations over an extended period of time

How to test whether the relationship is positive or negative

- (Abramitzky and Bouston, 2017) write: "We believe that there is a large scope for future work on the historical effects of immigrant arrivals on the US economy and society. Recent work on contemporary immigration flows has introduced improved identification strategies to study the effect of immigrants on native workers; these empirical innovations have yet to be fully incorporated into work on the Age of Mass Migration. The dramatic shift in immigration regime in the 1920s presents a potentially useful opportunity to design well-identified studies of the effect of immigration on the economy in this era."

How we test this relationship

- In this paper, we consider the closing of the United States' borders in the early 1920s.
- Before 1921, the United States had nearly open borders with Europe.
- By 1921, many people of Western European background became worried about the increasing portion of new immigrants from Southern and Eastern Europe.
- In 1921, and again in 1924, the United States enacted country-specific immigration quotas that targeted immigration from countries such as Italy and Russia, but not Great Britain or Norway.

Potential Strategy

- Some U.S. cities typically received immigrants from Southern and Eastern Europe.
- Other U.S. cities typically received immigrants from Western and Northern Europe.
- By comparing firms in both groups of U.S. cities with each other over time, we can see how firms that experienced a large decrease in overall immigration to their city compared to otherwise similar firms located in otherwise similar cities that did not experience a large decrease in overall immigration.

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- By comparing inventors and firms in both groups of U.S. cities with each other over time, we can see how inventors and firms that experienced a large decrease in overall immigration to their city compared to otherwise similar inventors and firms located in otherwise similar cities that did not experience a large decrease in overall immigration.
- In the last two years, seven papers have used the quotas to estimate the effects of mass migration on economic outcomes, but none of them have estimated its effects on innovation.
- We calculate exposure to the quota using the same quota-exposure formula as Ager and Hanson (April, 2018), also based on (Xie, 2017).

Total immigration inflows per fiscal year from administrative data

Immigration from Southern and Eastern Europe as a fraction of total immigration

History of Quotas

- 1921: annual quota of each nationality at 3% of the number of foreign-born persons of such nationality resident in the US in 1910
- 1924: annual quota of each nationality at 2% of the number of foreign-born persons of such nationality resident in the US in 1890

History of Quotas

- Before Quotas:
  - New Immigration from Scandanavia in 1921 = 22,854
  - New Immigration from Italy in 1921 = 222,260
- 1921 Quota:
  - Quota for Scandanavia after 1921 = 41,412
  - Quota for Italy after 1921 = 40,294

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- 1924 Quota:
  - Quota for Scandanavia after 1924 = 18,665
  - Quota for Italy after 1924 = 3,845

Annual Size of the 1924 Quota, by country

Northwest Europe and Scandinavia		Eastern and Southern Europe		Other Countries	
Germany	51,227	Poland	5,982	Africa	1,100
UK	34,007	Italy	3,845	Armenia	124
Ireland	28,567	Czechoslovakia	3,073	Australia	121
Sweden	9,561	Russia	2,248	Palestine	100
Norway	6,453	Yugoslavia	671	Syria	100
France	3,954	Romania	603	Turkey	100
Denmark	2,789	Portugal	503	Egypt	100
Total (Number)	142,483	Total (Number)	18,439	Total (Number)	3,745
Total (%)	86.50%	Total (%)	11.20%	Total (%)	2.30%

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History of Quotas

- Representative Ira Hersey of Maine: "We have thrown open wide our gates and through them have come other alien races, of alien blood, from Asia and southern Europe . . . with their strange and pagan rites, their babble of tongues."
- Senator Earl Michener of Michigan: "The Nordic People laid the foundations of society in America. They have builded this Republic, and nothing would be more unfair to them and their descendants than to turn over this Government and this land to those who had so little part in making us what we are"
- Senator Reed of Pennsylvania: "maintain the racial preponderance of the basic strain on our people and thereby to stabilize the ethnic composition of the population."

History of Quotas

- Lawmakers concerned about religion and ethnicity.
- No evidence that lawmakers anticipated that some locations would experience economic benefits from continued migration while others would experience economic costs from losing migrants.
- Lawmakers from regions slated to lose immigrants were supportive, as well as lawmakers whose regions that would not be affected.
- Far from local efforts to reduce all immigration to some locations but not others, these laws were national efforts to reduce all immigration from some sources but not others.

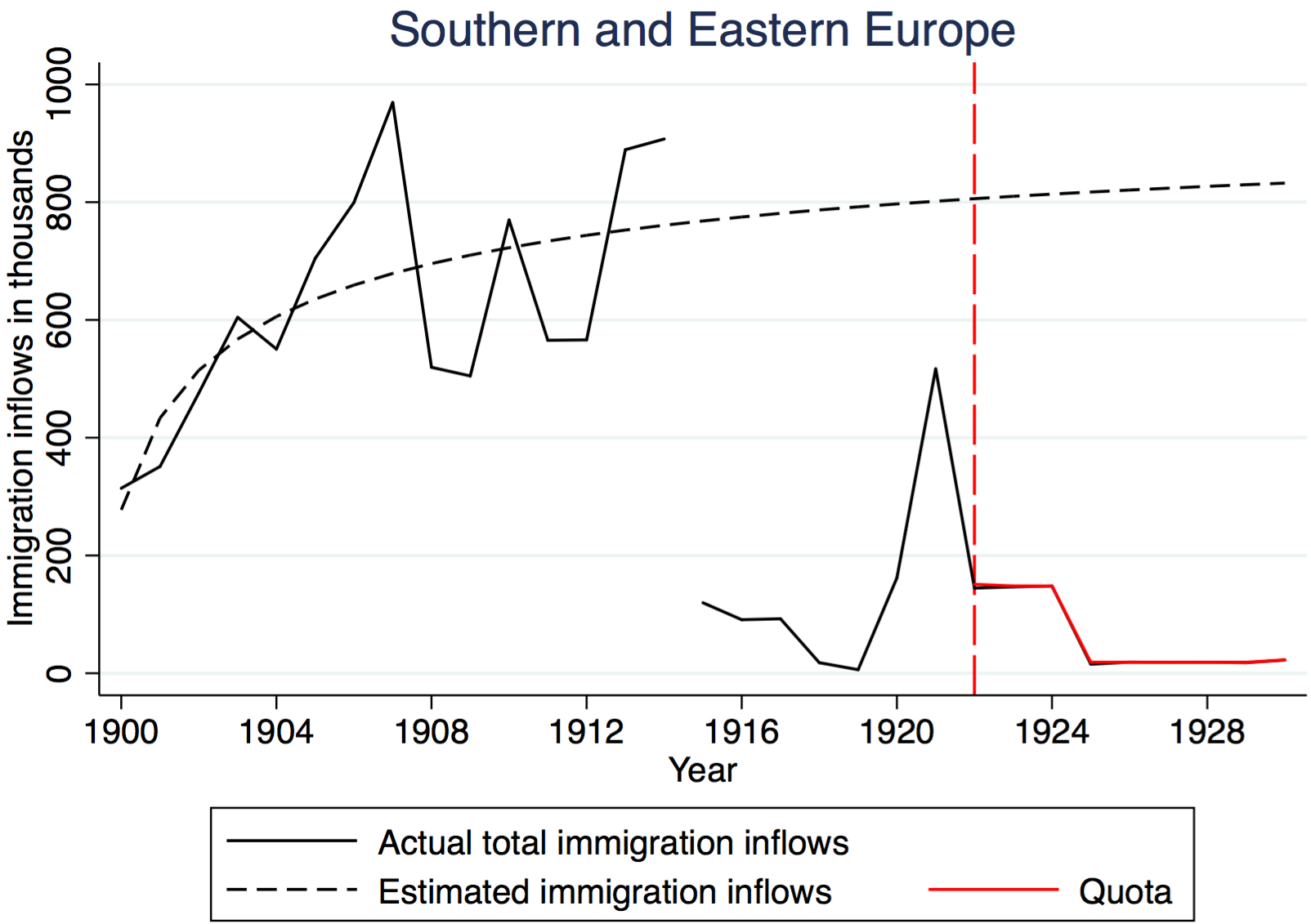
Exceptions to Quotas

- Many categories of immigrants were granted blanket exceptions to the quotas and could therefore continue to immigrate without restrictions, including:
  - "professors" and "lecturers"
  - people belonging to "any recognized learned profession"
  - "an immigrant who is a bona fide student at least 15 years of age and who seeks to enter the United States solely for the purpose of study"
  - domestic servants (from 1921-1924)
  - singers and actors

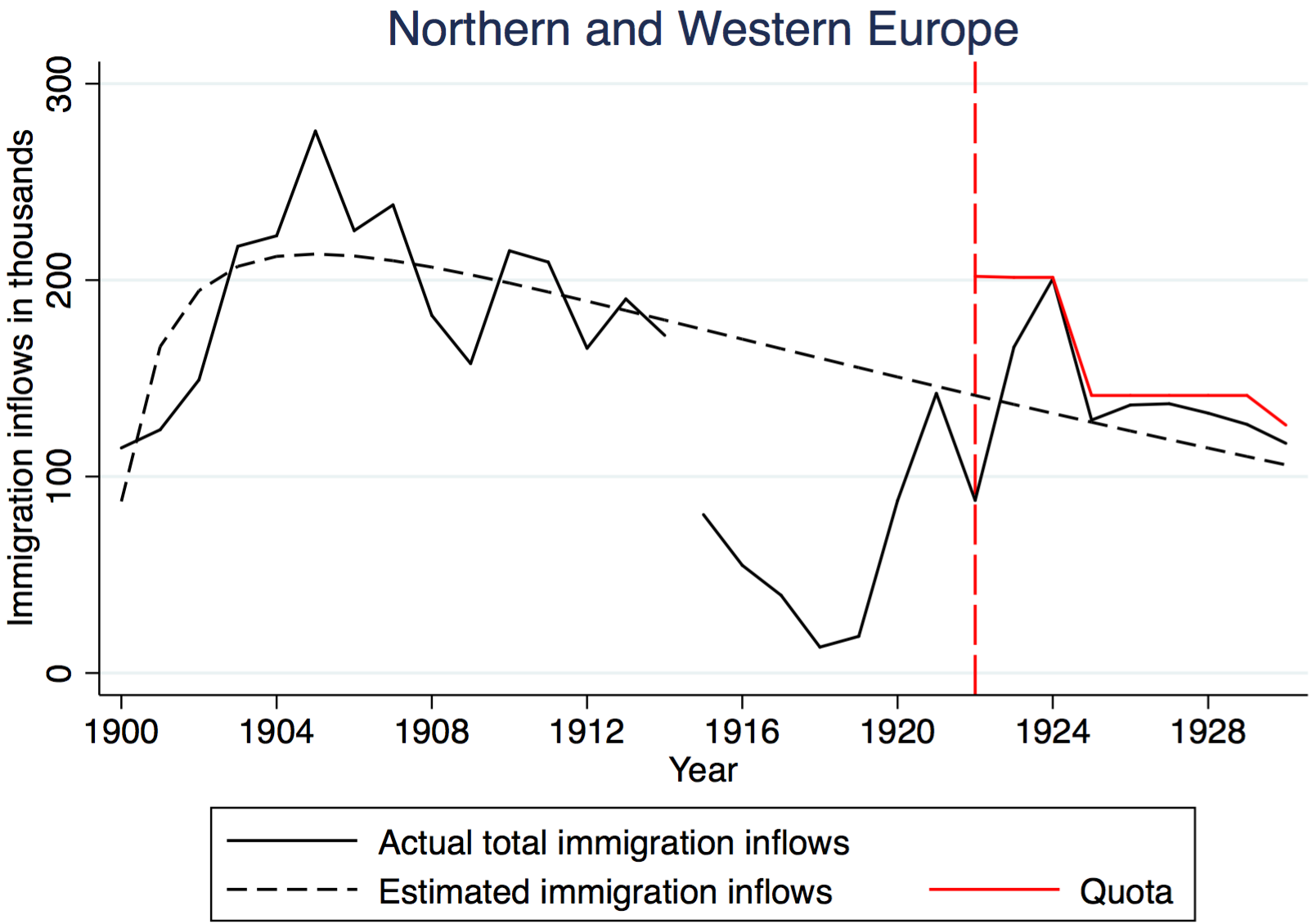
How many immigrants were "missing" due to the Quotas?

- Following (Ager and Hanson, 2018) and (Xie, 2017), we can project earlier immigration flows by source country forward in time, and calculate the difference between what immigration we would have expected based on previous flows and what we got under the quotas.
- We do this twice, once for Southern and Eastern Europe source countries, and once for Northern and Western Europe source countries.

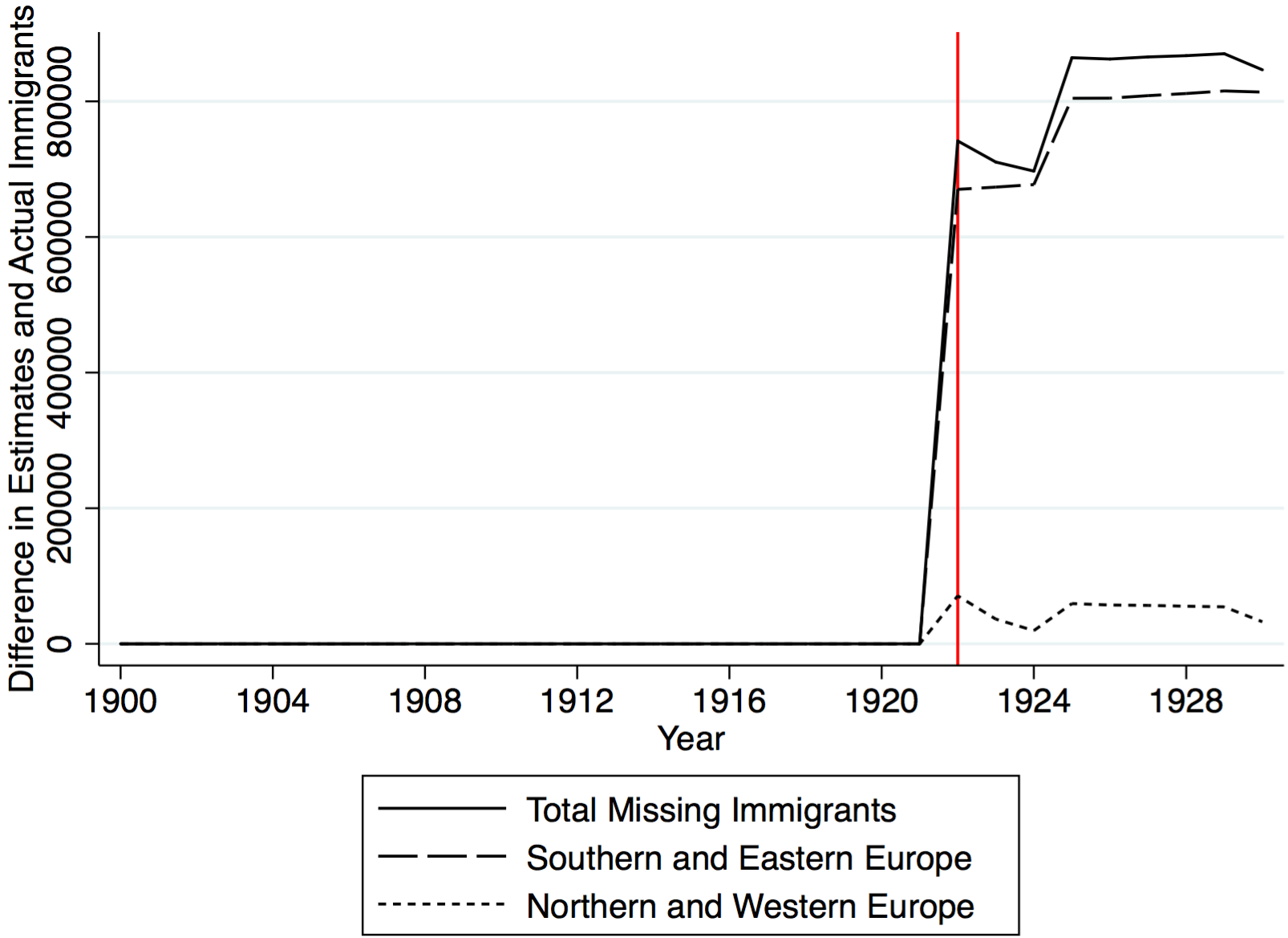
Immigration inflows versus quota



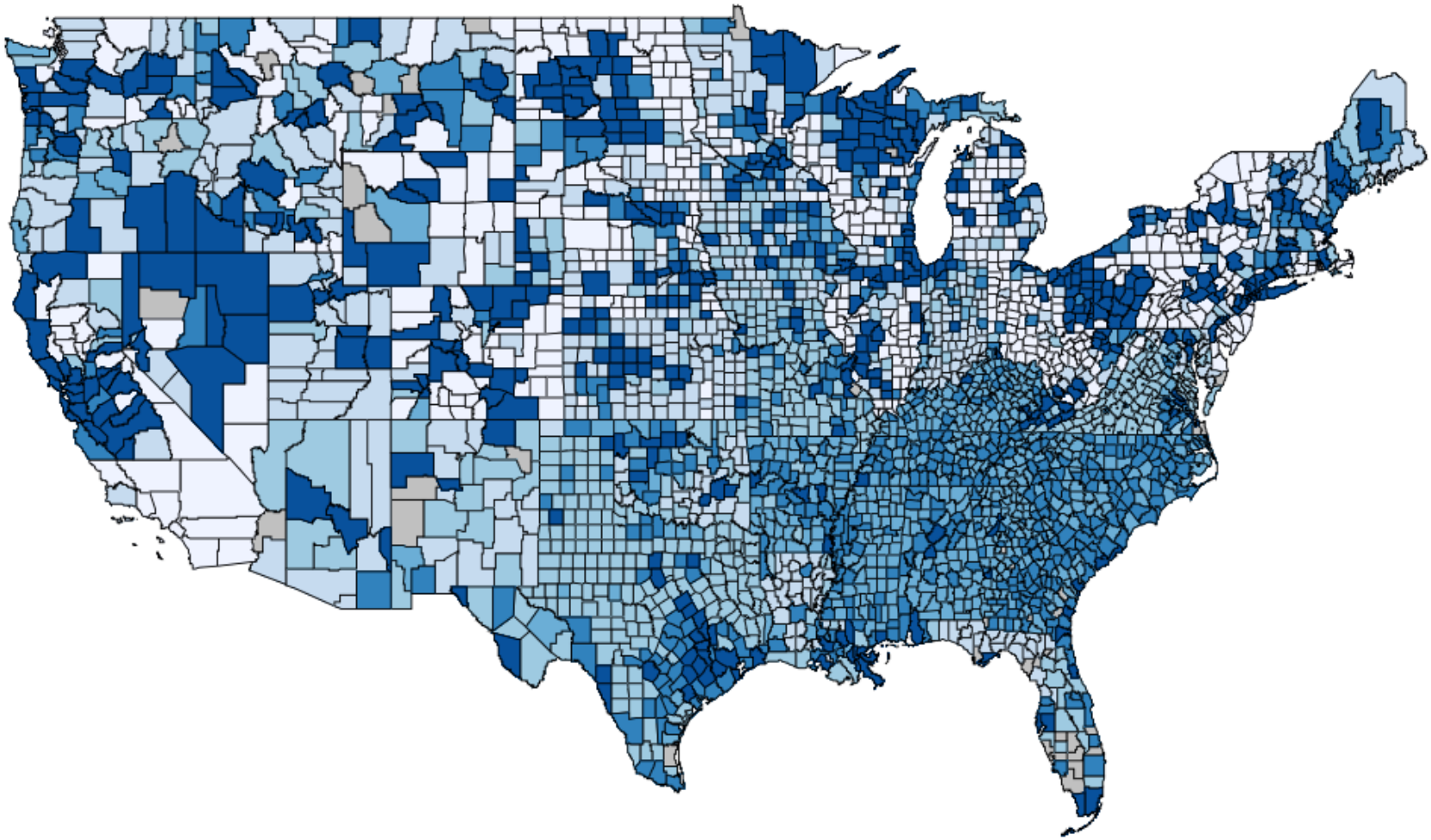
Immigration inflows versus quota



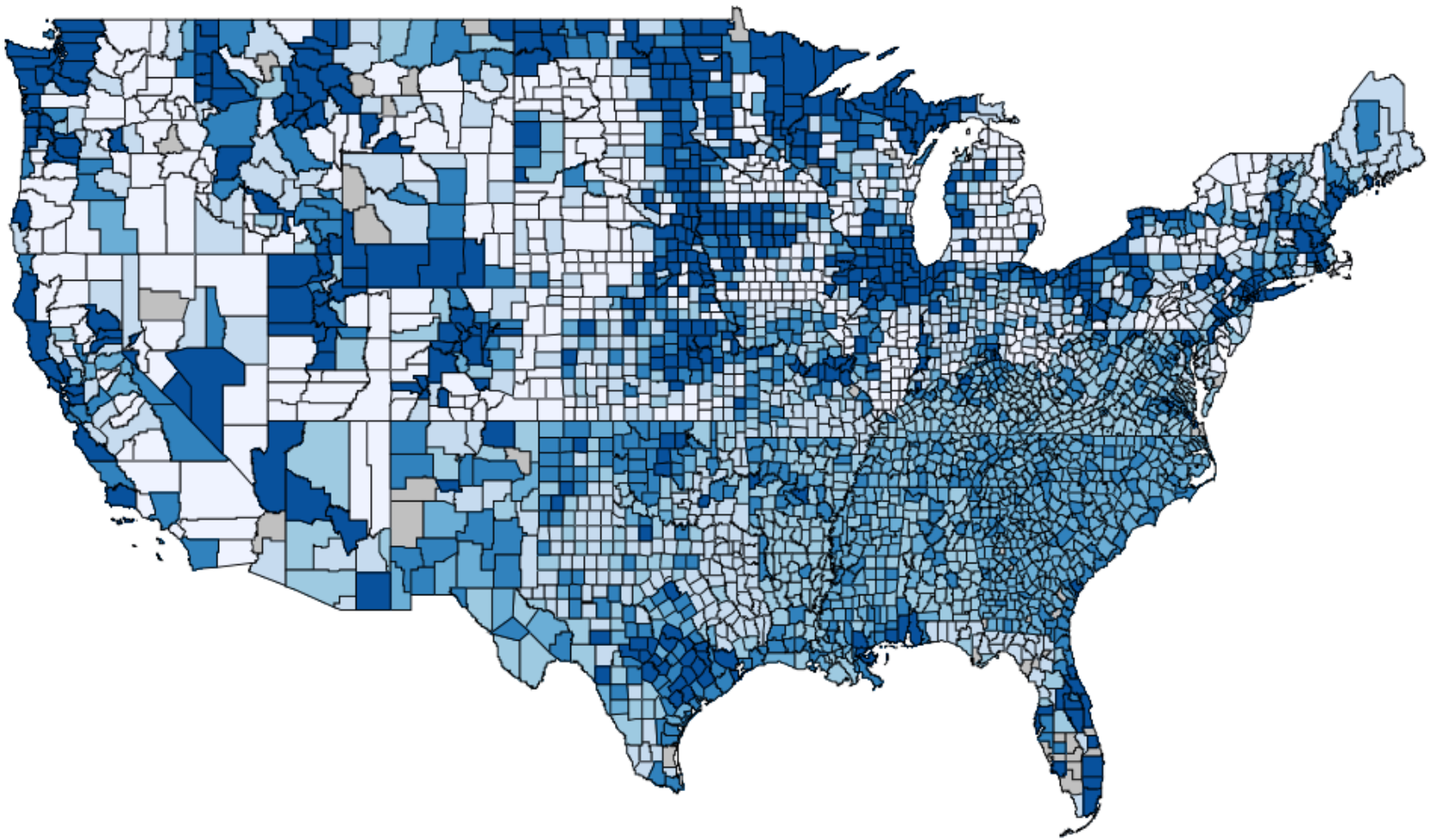
Missing immigration inflows under quota



Geographic distribution of foreign born from Southern and Eastern Europe as a fraction of 1920 total population conditional on state fixed effects



Geographic distribution of foreign born from Northern and Western Europe as a fraction of 1920 total population conditional on state fixed effects



Treated cities

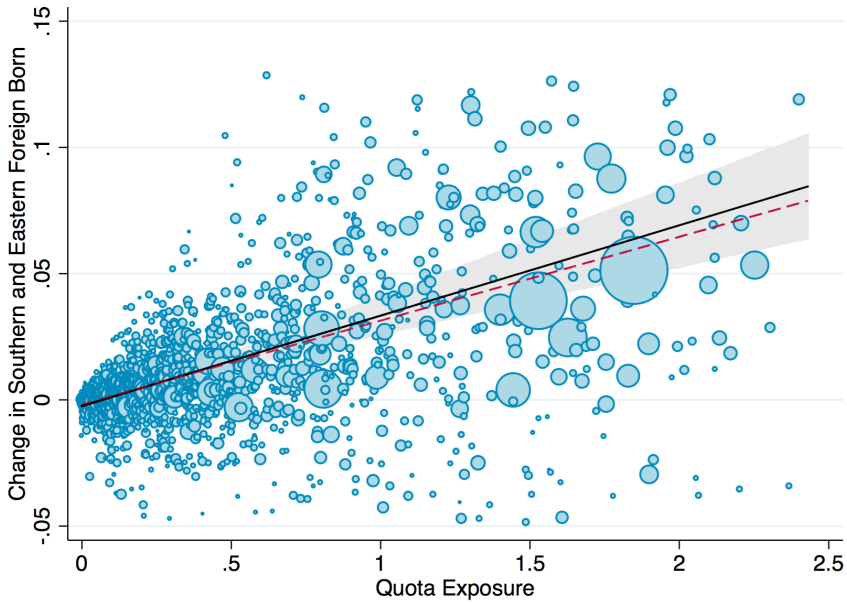
- There are 3,339 cities in our data. each city, we calculate its quota exposure:

$$QuotaExposure_c = \frac{100}{P_{c,1920}} \sum_{j=1}^{J} \left(\widehat{I}_{j,22-30} - Quota_{j,22-30} \right) \frac{FB_{jc,1920}}{FB_{j,1920}} \tag{1}$$

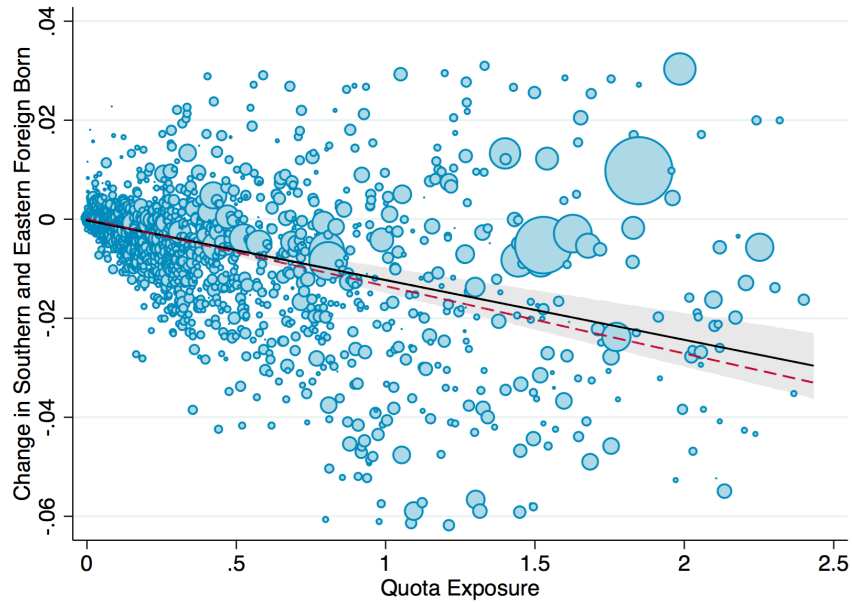
  where $\widehat{I}_{j,22-30}$ is the estimated average immigration inflows per year from country j during the post-quota years from 1922 and 1930 if the quota acts had not been enacted.
- The variable $QuotaExposure_c$ represents the average annual number of "missing" immigrants per-100-inhabitants in city c due to quotas.
- We also construct an analogous measure for Quota Exposure at the industry level

Change in foreign born population from Southern and Eastern Europe:

1910-1920



1920-1930



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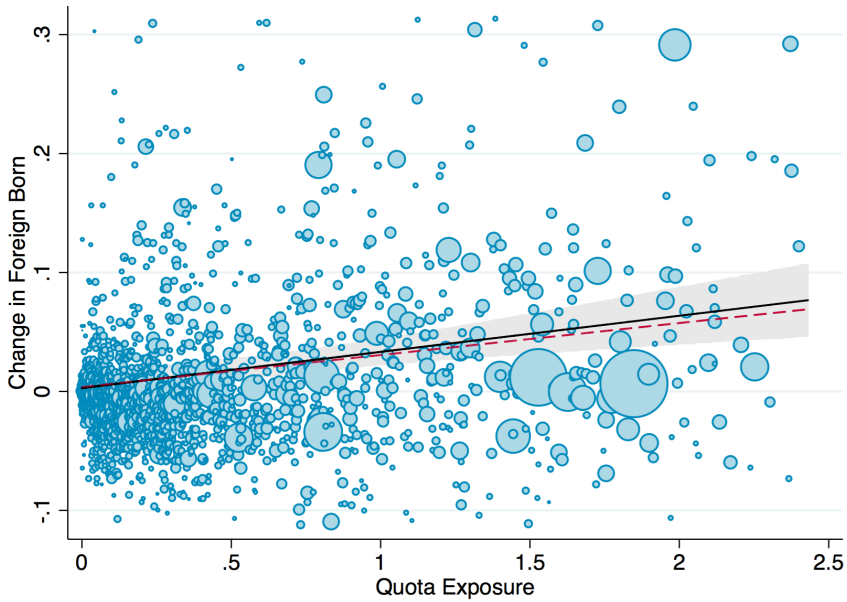
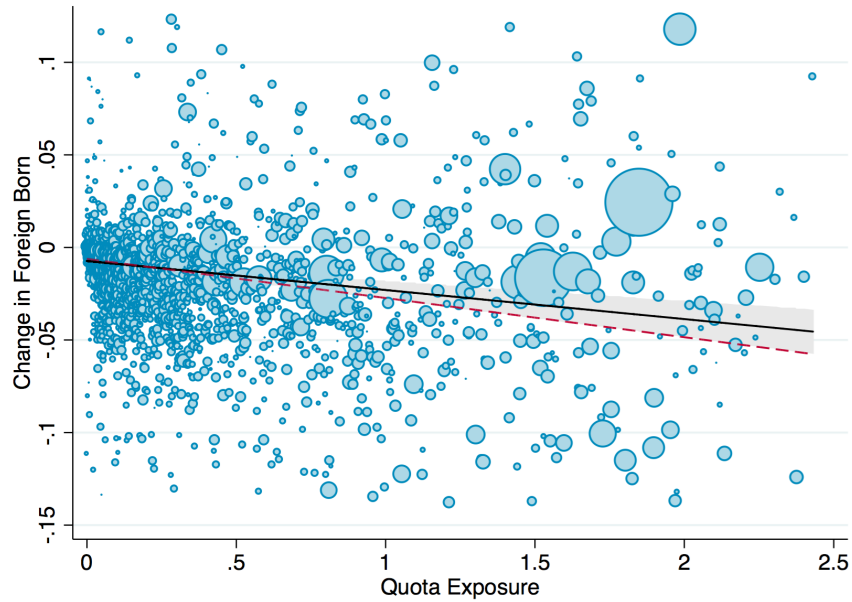
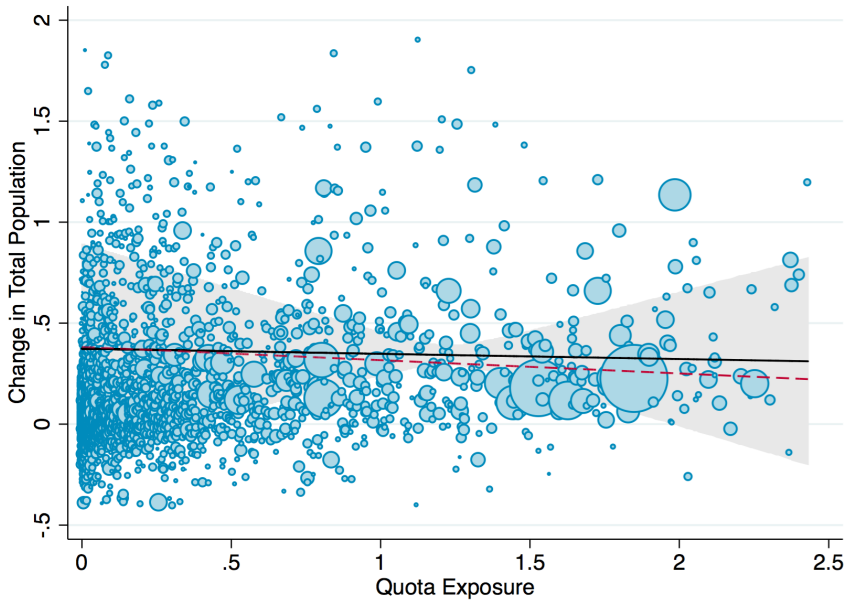


1920-1930

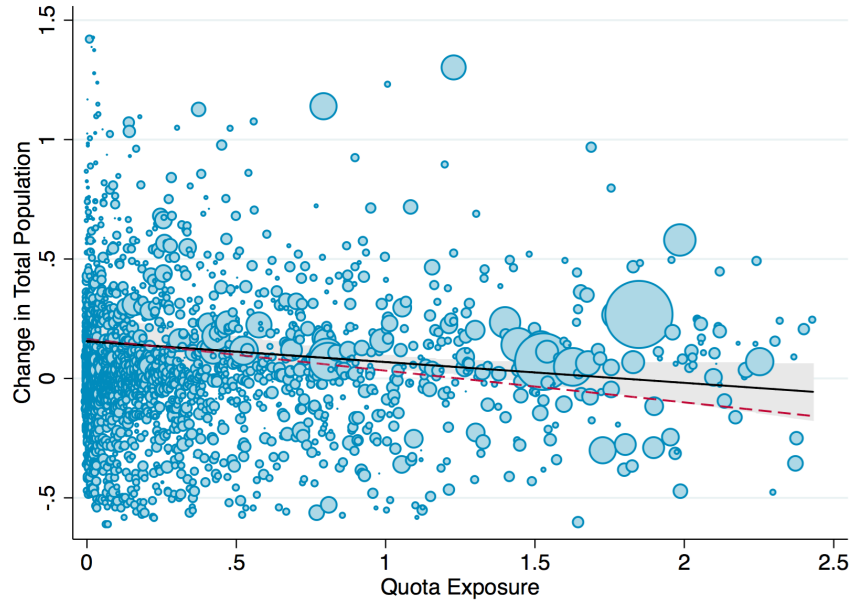


Change in total population:

1910-1920



1920-1930



Effect of Quota on Population and Workforce

	Southern/Eastern FB		Foreign Born		Total	
	1910-1920	1920-1930	1910-1920	1920-1930	1910-1920	1920-1930
Dependent Variable: Change in Population as a Fraction of Total City Population						
Quota	0.0358***	-0.0121***	0.0304***	-0.0157***	-0.0257	-0.0870*
	(0.0047)	(0.0014)	(0.0081)	(0.0027)	(0.2141)	(0.0450)
Mean	0.0082	-0.0038	0.0119	-0.0117	0.3660	0.1301
Cities	3208	3327	3208	3327	3208	3327
R-squared	0.1691	0.1230	0.0028	0.0173	0.0000	0.0004
Dependent Variable: Change in Workers as a Fraction of Total City Population						
Quota	0.0092***	-0.0062***	-0.0013	-0.0074***	-0.0188	-0.0292**
	(0.0029)	(0.0008)	(0.0046)	(0.0014)	(0.0551)	(0.0145)
Mean	0.0010	-0.0018	-0.0030	-0.0043	0.0481	0.0520
Cities	3206	3323	3206	3323	3206	3323
R-squared	0.0561	0.0996	0.0000	0.0151	0.0000	0.0004

Effect of Quota on Immigrant Inflows

Dependent Variable: New Immigrants as a Fraction of 1910 Population

	1900-1929		1919-1929	
	Post-Treatment Year			
	1922	1924	1922	1924
Quota × Post	-0.0036***	-0.0037***	-0.0010***	-0.0015***
	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Dep.Var.Mean	0.0029	0.0028	0.0022	0.0022
N	92190	92190	33803	33803
Cities	3073	3073	3073	3073
R-squared	0.5708	0.5691	0.6495	0.6534

How did inventors in these cities respond?

- First, we consider the shock at the geographical location level
- We observe people living in treated and control cities in 1919 (observed in 1920 US Census).
- First sample of interest: people who have already completed at least one patent by the year 1919 (pre-existing inventors).
- We need the data to accomplish this.

Merging Patents into the Census

- We use a fuzzy matching procedure to merge patents at the individual-name level into the 1900, 1910, 1920, 1930, and 1940 US Censuses.
- Idea: each US Census tells us how many people living in the US at that time had your unique first name, middle name, and last name combination.
- Almost half of the population is made up of people who are the only person in the country with their first name, middle name, and last name combination.

Merging Patents into the Census

- Names restriction: 43% of US population made up of people with unique names in 1920 Census
- Years restriction: patents by these people btwn ages of 18 and 80
- How plausible is the merge?
  - If you have a unique name in the 1920 Census (observed in 1919), then any patents applied in the years 1919 through 1929 with your unique name must either be from you, or from someone who immigrated to the United States with your unique name during those years. They could not be from someone born after 1919 with your unique name, because any such person would be younger than 10 years old. They could not be from someone born before 1919 who died by 1919, because such a person would be dead.

Difference-in-Differences Specifications

- We estimate regressions of the following form:

$$Y_{ict} = \alpha + \beta(Quota_c \times Post_t) + X_{it} + \tau_t + \gamma_i + \epsilon_{ict}$$

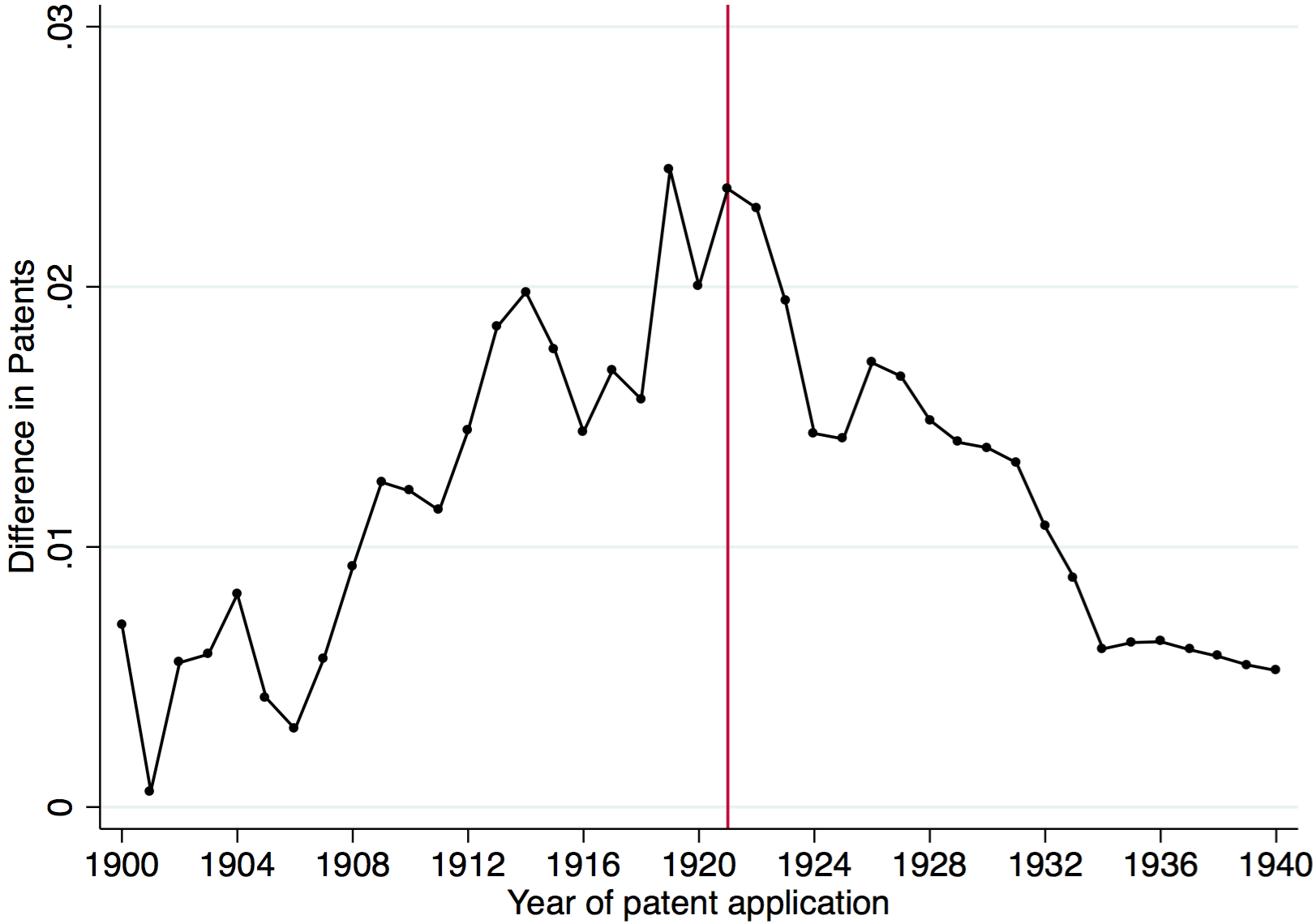
- Y_{ict}: The number of patents or citations of person i in year t
- $Quota_c$: Quota exposure of city c
- $Post_t$: 1 if year $\geq$ 1924, 0 otherwise
- X_{it}: Quartic of age of person i in year t
- Standard errors are clustered at the individual level.

Difference-in-Differences Results

Dependent Variable: Patents by Incumbent Inventors in 1919

	1900-1950		1919-1929	
	Post-Treatment Year			
	1922	1924	1922	1924
Quota × Post	-0.0018**	-0.0031***	-0.0037***	-0.0046***
	(0.0009)	(0.0009)	(0.0012)	(0.0011)
Dep.Var.Mean	0.1252	0.1206	0.1060	0.0936
N	6577575	6577575	1573627	1573627
Inventors	145842	145842	145842	145842
Cities	3311	3311	3311	3311
R-squared	0.2327	0.2327	0.4003	0.4003

Difference in patent applications per year between highly exposed inventors and comparison inventors;



Magnitudes

- Pre-existing inventors completed 0.5% fewer patents per year for every 10% fewer immigrants entering their city that year.

Mechanisms

- There are many possible mechanisms through which mass migration may affect invention
- Immigration can affect the whole local economy
- Let's consider three specific possibilities:
  - Maybe a small number of immigrant inventors are responsible for spillovers
  - Maybe immigrant domestic servants free up the time of inventors to do more invention
  - Maybe a simple case of increased scale available for production

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Mechanisms

- Did inventors decrease applications for *all* patents, or just for patents relevant for industries that had depended on immigrants to maintain their production scale?

Mechanisms

- To test this hypothesis, we first determine whether some industries were more exposed to the quotas than others. We estimate the following equation at the industry-year level:

$$Y_{jt} = \alpha + \beta(QuotaExposure_j \times PostTreatment_t) + \tau_t + \gamma_j + \epsilon_{jt} \quad (2)$$

where Y_{jt} is the number of newly arrived immigrants per year into industry j rescaled by 1920 total workers in that industry j.

Difference-in-Differences Results

Dependent Variable: Industry Immigration Inflows as a Fraction of Total Workers

	1900-1929		1919-1929	
	Post-Treatment Year			
	1922	1924	1922	1924
Quota × Post	-0.0944*	-0.0777**	-0.0593	-0.0307***
	(0.0524)	(0.0378)	(0.0359)	(0.0112)
Dep.Var.Mean	0.0157	0.0190	0.0207	0.0280
N	2920	2920	1606	1606
Industries	146	146	146	146
R-squared	0.4073	0.4056	0.7682	0.7677

Mechanisms

- How much of the decline in patents by incumbent inventors in quota affected locations can be attributed to their decline in patents relevant for local quota-affected industries?
- How much of the decline in patents can be attributed to a decline in patents for non-quota affected industries?

Difference-in-Differences Results

Dependent Variable: Patents Related to Affected Industry

	1900-1950		1919-1929	
	Post-Treatment Year			
	1922	1924	1922	1924
Quota × Post	-0.0034***	-0.0041***	-0.0045***	-0.0048***
	(0.0012)	(0.0012)	(0.0017)	(0.0015)
Dep.Var.Mean	0.0965	0.0853	0.0748	0.0727
N	1572390	1572390	870996	870996
Inventors	145842	145842	81308	81308
Cities	3311	3311	3274	3274
R-squared	0.4271	0.4271	0.4974	0.4974

Difference-in-Differences Results

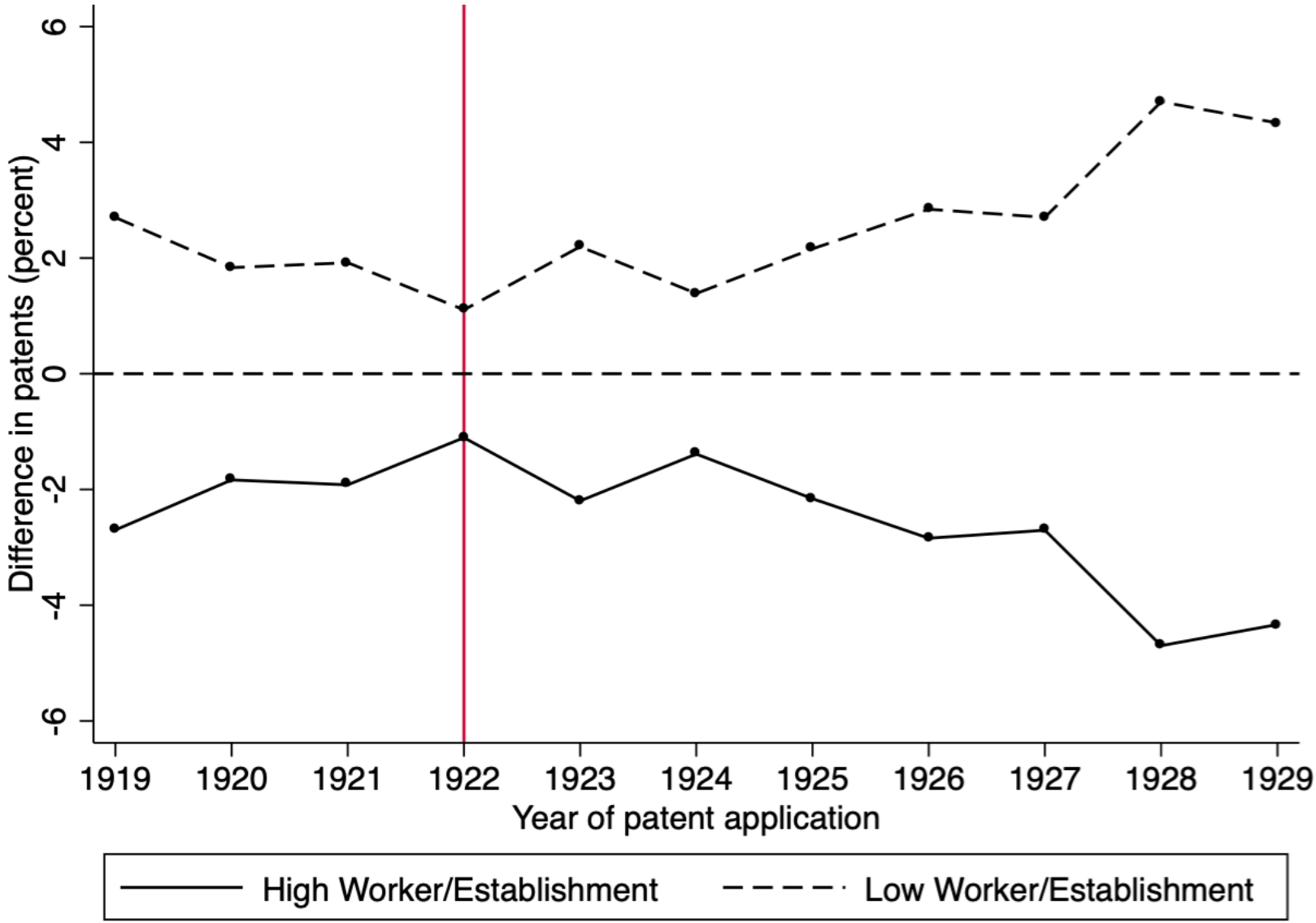
Dependent Variable: Patents Unrelated to Affected Industry

	1900-1950		1919-1929	
	Post-Treatment Year			
	1922	1924	1922	1924
Quota × Post	-0.0004	-0.0005	0.0004	0.0001
	(0.0003)	(0.0003)	(0.0004)	(0.0004)
Dep.Var.Mean	0.0078	0.0071	0.0056	0.0054
N	1572390	1572390	870996	870996
Inventors	145842	145842	81308	81308
Cities	3311	3311	3274	3274
R-squared	0.2853	0.2853	0.2750	0.2750

Mechanisms

- It is apparent that nearly all of the reduction in patent applications reported in the main results was due to a reduction in applications relevant for highly quota-exposed industries (those with quota-exposure above the 75th percentile). Patent applications relevant for non-highly quota-exposed industries did not significantly change.
- These results suggest that what declined substantially after the quotas was the invention of technology relevant for industries that lost workers due to the quotas.
- In these industries, labor became scarce, and this discouraged particular types of invention.
- In the context of (Acemoglu, 2010), this suggests that much of the invention at the time was "strongly labor-complementary".

Patents relevant for small establishments vs. large establishments



Additional Mechanisms

- The Quotas decreased immigration and decreased patenting.
- We argue that one mechanism at work is a scale effect due to the overall decline in mass migration.
- The scale effect can account for nearly all the decline in patents.
- But it's possible that other mechanisms could be at work as well
- With such a large shock, it's always possible that some small specific subset of missing immigrants could be particularly important for the patenting effects.
- We will consider two such subsets of immigrants.

Additional Mechanisms

- One such subset is immigrant inventors.
- The Quotas were not intended to limit exceptionally highly skilled individuals.
- But what if the Quotas inadvertently prevented highly prolific scientists and inventors from migrating?
- The effects could then be due in part to lost knowledge spillovers.
- But when we look at the migration of inventors born in Europe who had patent applications before their migration, we do not see any treatment effect on net inventor migration to quota-exposed locations.

Additional Mechanisms

- Did household help occupations lose immigrants after the shock?
- This could provide an additional mechanism for the effects (Cortes and Tessada, 2011); (Cortes and Pan, 2013).
- Our preliminary work here shows no change in domestic service occupations.

Further Results

- New inventors and young inventors both *increased* their rate of patent applications after the quotas.
- Incumbent and older inventors took longer to adjust, a result consistent with (Borjas and Doran, 2015).
- Firms responded to this shock in two ways: by avoiding geographically-located shocks through geographic mobility, and avoiding industry-wide shocks through mobility in the space of ideas.

Conclusions

- In this paper, we provide the first causal evidence on the effect of mass immigration on U.S. inventors.
- We do so at the end of the largest international migration in history, during the tail end of America's second Industrial Revolution.
- Our results suggest that a ten percent reduction in mostly low-skilled immigration results in a 0.5 percent reduction in the number of patent applications by incumbent U.S. inventors.

Conclusions

- The results are not an artifact of a changing pool of inventors, differential pre-quota trends, or the loss of uncited patent applications.
- inventors applied for fewer patents relevant for industries that lost immigrant workers, and a smaller share of their applications were relevant for industries with large establishments.
- the pattern of inventions characteristic of America's second industrial revolution may have irrevocably changed with the long-term loss of mass unskilled migration.

Conclusions

- From a historical perspective, therefore, it appears that it was not necessity that was the mother of invention, but rather opportunity.