Mass Migration and Technological Change

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Introduction

- The *Age of Mass Migration* (1850–1920)
  - About 1/4 of the Swedish population emigrated.
- Period of large political and economic change.
- What role did emigration play?
- Two papers:
  1. Political effects
  2. Economic effects [Today's presentation]

Introduction

- We focus on sending locations – comparing municipalities with high and low *emigration*.
  - Understudied: most attention in the literature on receiving locations.
- Question: How did emigration affect technological change?
- Outcomes:
  1. Innovation (all patents up to 1914)
  2. Labor and capital input use in agriculture and industry

Introduction

- How may emigration affect technological change?

  Through its effect on human capital

  - "Brain drain" and "brain gain" (Beine et al, 2011)
  - Flow of information and physical return migration.

  ...and similarly on economic flows from the US

  - Remittances and physical return migration may include capital flows.

  Through its effect on the cost of labor

  - may induce labor-saving innovation (Hicks, 1932; Habakkuk, 1962; Acemoglu, 2010).
  - may interact with structural change (Ljungberg, 1997; Allen, 2009)

Preview of results

- Data and variation we use (more on this shortly):
  - all registered emigrants (and return migrants).
  - variation in emigration based on instrumental variable (frost shocks and proximity to ports).

- More emigration led to
  1. increases in innovative activity (measured by patents).
  2. increased adoption of new technologies both within agricultural and industrial sector.
  3. *(i)* Higher (un-skilled) wages in agriculture, *(ii)* employment shifts towards industrial sector, and *(iii)* higher (corporate) firm profits and local tax revenues.
  - Find limited role of return flows from the United States in explaining our results.

Roadmap

Background and Data

Empirical strategy

Results

Background

- The Age of Mass Migration (1850-1920).
  - 30 million Europeans migrate to the US.
- Sweden during this time:
  - About 25% emigrate 1867–1914.
  - Rapidly rising wages
  - Industrial and technological revolution
- Sweden poor, agrarian economy in the 1860s.
  - 80% agricultural population (Edvinsson, 2005).
  - Abundant in low-wage labor (Hovde, 1934; Hecksher, 1941).
  - Production processes highly labor intensive (Hecksher, 1941).

Background: first wave of mass emigration

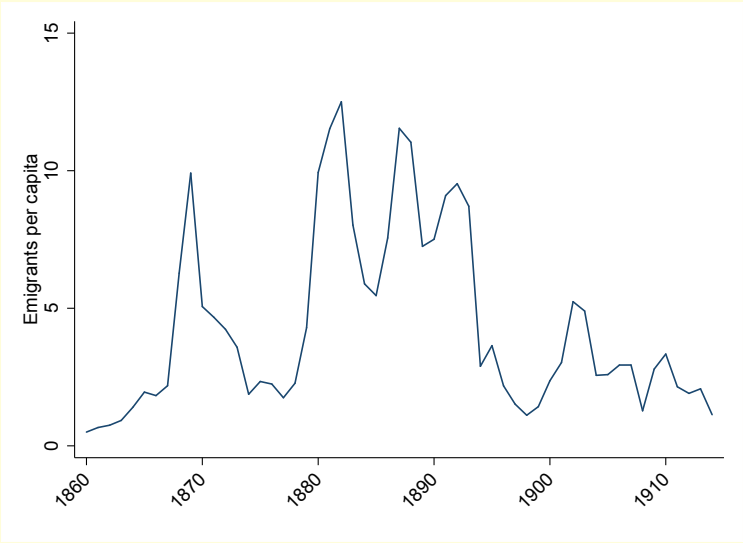
- Emigration takes off in large numbers late 1860s.
- Famine years crucial push factor (Sundbärg, 1913; Barton, 1994; Beijbom, 1995). Low temperatures, frost.
- Migrants exit mainly via two ports: Gothenburg and Malmö (97%).

Background: later emigration

- Social networks important for subsequent emigration:
  - Every second migrant traveled on pre-paid tickets (Runblom & Norman, 1976; Beijbom, 1995).
  - Survey (1908–09): 93.6% of Scandinavian migrants joining friends or relatives (Hatton, 1995).

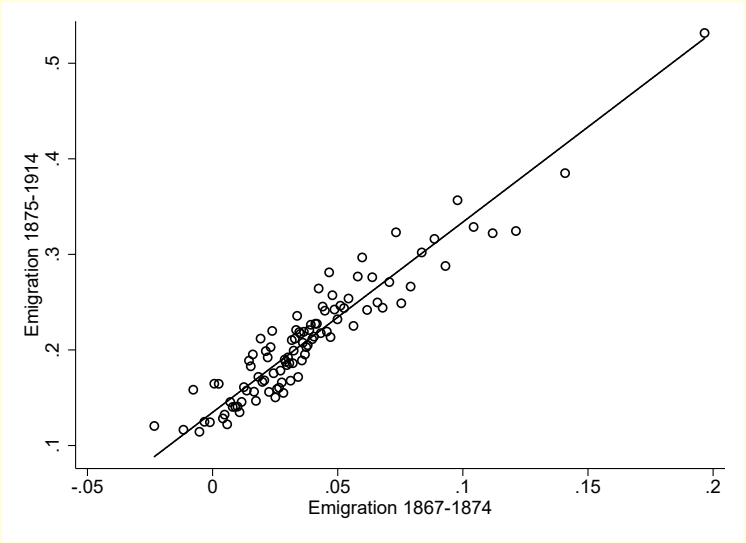
- Path dependence important feature for our identification strategy.
  - Determinants of early migration also predict long-term flows.

Swedish emigration 1860–1914



Notes: Total number of migrants per 1,000 inhabitants.

Early and late migration rates



Notes: Binned scatter plot between early emigration (1867–1874) and later emigration (1875–1914) in per capita 1865. Both emigration variables are residuals after controlling for our baseline set of covariates. Municipalities are grouped into 100 bins of equal size.

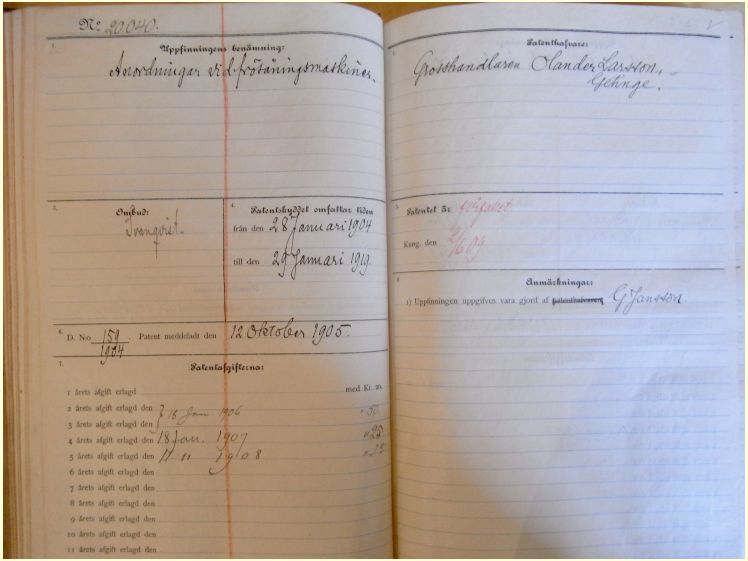
Background: Swedish industrialization

- Sweden industrializes in the late 1800s.
  - Industry grows in rural areas (eg. Heckscher, 1941; Ljungberg, 1996).

- Emigration and the labor market.
  - Shortage of labor (Sundbärg, 1913; Hovde, 1934) and low-skilled wage increases (Ljungberg, 1997).
  - Agricultural interests lobby against emigration (Kälvemark, 1974).
  - Increase in labor costs due to stronger labor unions (Karadja & Prawitz, 2019; Schön, 2000).

- Technological advances related to labor.
  - Emigration induced greater usage of machines (Sjöström, 1922).
  - Regional spread of new technology mostly explained by wages differences (Gadd, 2017).
  - Producers forced to mechanize to lower labor costs (Schön, 2007).

From the Archives



Data

- Data set with nearly 2,400 municipalities.
- $\approx$ 17,000 patent obs. linked to a municipality.
  - name, address, occupation, patent fees.
- Migrants from two sources: church books and passenger lists.
- Daily weather data from Swedish and Norwegian weather stations etc.

Summary stats

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Empirical strategy

- Cross-sectional equation of the following form:

$$ln(Patents_{ic}^{1867-1914}) = \beta ln(Emigrants_{ic}^{1867-1914}) + \gamma ln(Population_{ic}^{1865}) + \mathbf{X}'_{ic}\delta + \theta_c + \varepsilon_{ic},$$

- OLS may not estimate the causal effect.
  - bias due to confounding factors or reverse causation
  - attenuation bias (measurement error in migration)

Instrument

- Determinants of early emigration explain long-term flows.

- IV uses the interaction of two variables:
  1. growing-season frost shocks 1864–67 Definition
  2. proximity to migration port (Gothenburg or Malmö)

- Intuition: marginal effect of a frost shock is larger when close to the port.

Instrument

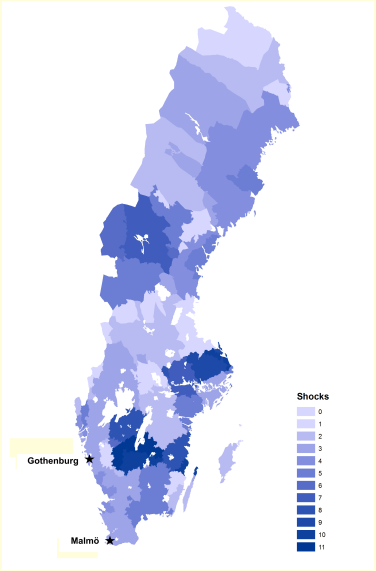
- First stage:

$$ln(Emigrants_{ic}^{1867-1914}) = \beta_1 \underbrace{Frost_{ic} \times Port_{ic}}_{Instrument} + \underbrace{\beta_2 Shocks_{ic} + \beta_3 Port_{ic}}_{Controls} + \mathbf{X}'_{ic}\delta + \theta_c + u_{ic}$$

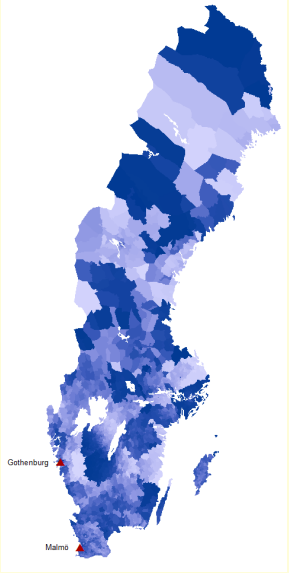
Instrument

- Exclusion restriction: do frost shocks have different impacts depending on port proximity?
- Gothenburg and Malmö largest cities and trade ports.
- But there were other trade ports, notably Stockholm and Norrköping, that had very little emigration.
- Solution: Interact shocks with proximity to nearest trade port/town.

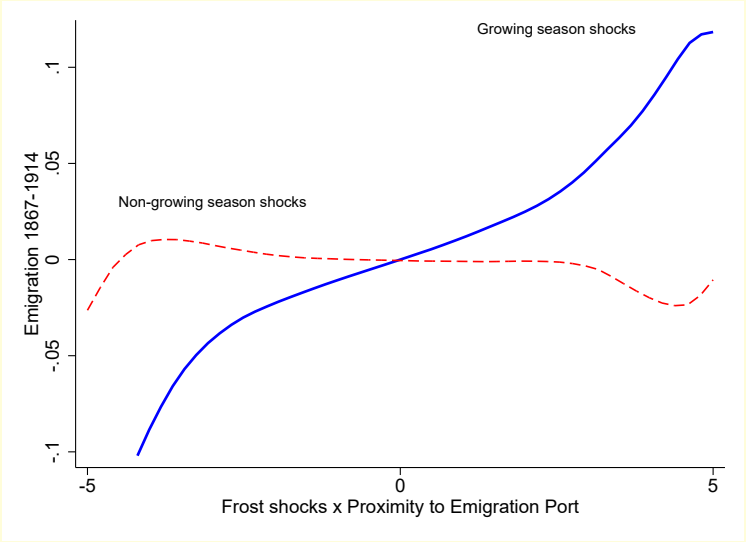
Spatial distribution of frost shocks



Spatial distribution of the instrument



First-stage and placebo



Notes: Local polynomial smooth for the relationship between emigration and the instrument (solid line) and the placebo instrument (dashed line), conditional on controls.

Emigration increases innovation

Dependent variable:	Emigrants			
	(1)	(2)	(3)	(4)
Shocks×Emigration port proximity	0.064***	0.060***	0.062***	0.061***
	(0.016)	(0.013)	(0.014)	(0.015)
Shocks	0.004	0.013**	0.010	0.007
	(0.006)	(0.006)	(0.009)	(0.010)
Shocks×Trade port proximity			-0.015	-0.010
			(0.022)	(0.021)
Shocks×Town proximity			0.002	0.003
			(0.008)	(0.008)
NGS Shocks×Emigration port proximity				-0.003
				(0.017)
NGS Shocks				0.012
				(0.013)
Region FE	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes
Observations	2388	2388	2388	2388
Mean dep. var.	5.39	5.39	5.39	5.39

Notes: OLS and 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Roadmap

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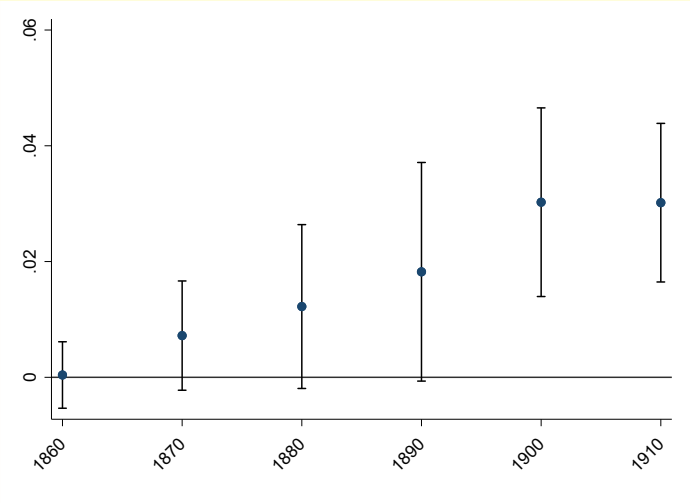
Reduced-form effect on innovation



Notes: Reduced-form effect of instrument on log number of patents by decade, starting in the denoted year. Final point refers to 1910–1914. 95% confidence intervals.

Emigration increases innovation

Dependent variable:	Patents				
	OLS		IV		
	(1)	(2)	(3)	(4)	(5)
Emigrants 1867–1914	0.375***	0.263***	0.739**	0.569**	0.598***
	(0.061)	(0.040)	(0.318)	(0.264)	(0.225)
Region FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	Yes
Market access controls	No	No	No	No	Yes
Observations	2388	2388	2388	2388	2388
F-stat			15.71	21.10	20.31
Mean dep. var.	0.62	0.62	0.62	0.62	0.62

Notes: OLS and 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Emigration increases innovation – upper tail

Dependent variable:	At least *n* patents 1867-1914				
	1	2	3	4	5
	(1)	(2)	(3)	(4)	(5)
Emigrants	0.072	0.169*	0.183**	0.225***	0.226***
	(0.108)	(0.093)	(0.085)	(0.081)	(0.075)
Region FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
Market access controls	Yes	Yes	Yes	Yes	Yes
Observations	2388	2388	2388	2388	2388
F-stat	20.31	20.31	20.31	20.31	20.31
Mean dep. var.	0.37	0.26	0.20	0.16	0.14

Notes: OLS and 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Economic value of patents

- Patents could be prolonged yearly at a cost.
- Proxy for the economic value of patents (see eg. Schankerman and Pakes, 1986; Burhop, 2010).
- Patent prolongation:
  - maximum 15 years
  - increasing fees over duration
  - total cost corresponds cost of keeping patent 15 years today (Andersson & Tell, 2016)

Economic value of patents

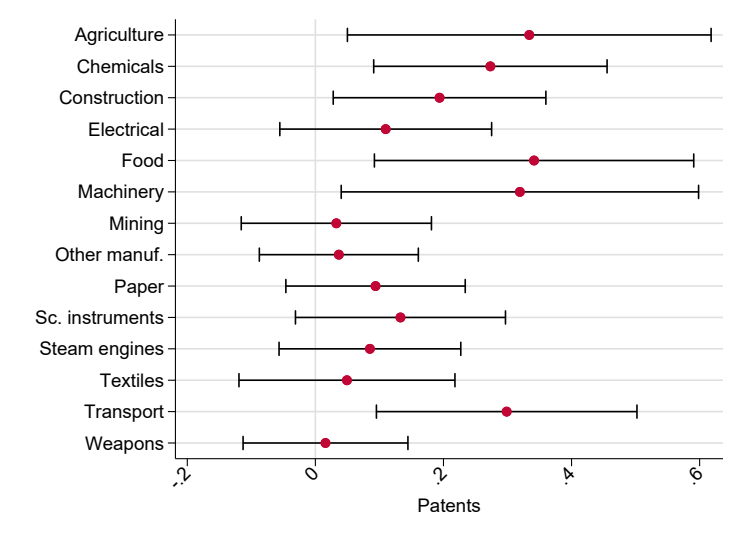
Dependent variable:	Log value-weighted patents 1885–1914				
	OLS		IV		
	(1)	(2)	(3)	(4)	(5)
Emigrants 1867–1914	0.510***	0.365***	1.045**	0.852**	0.927***
	(0.077)	(0.056)	(0.487)	(0.398)	(0.335)
Region FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	Yes
Market access controls	No	No	No	No	Yes
Observations	2388	2388	2388	2388	2388
F-stat			15.71	21.10	20.31
Mean dep. var.	0.99	0.99	0.99	0.99	0.99

Notes: OLS and 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Economic value of patents

- We find positive effects on the number of patents weighted by their length.
- Indicates that the patents created by emigration had economic value.

Effects across patent classes



Notes: IV effect of emigration on different patent categories.

Effects across patent classes

- Positive effects on innovation across several patent classes.
- Large effects in agriculture, food, and machinery, all labor-intensive areas.
- Agriculture also likely experienced the largest labor supply shock.
  - Consistent with labor-saving innovation.
- Can we generalize this? Do we see that emigration tied to certain patent classes also affects innovation in those classes?

Effects across patent classes

- We assign emigrants to DPK patent classes and run patent-level regressions.
- 2388 municipalities * 89 patent classes: 200,000+ observations.
- No instrument in this setting, but we can add municipality fixed effects.
- Recall OLS-IV comparison indicates OLS underestimates effect.
- Mapping emigrants to patent classes is not straightforward.
  1. Start with subset of emigrants in our data for which we know pre-emigration occupation.
  2. Match these occupations to patent classes: (e.g. miners $\rightarrow$ mining patents, farm workers $\rightarrow$ agricultural patents).
  3. Use this to create, for each municipality, an estimate of the number of emigrants by patent class.

Both local and national level emigration matter

Dependent variable:	Patents				
	(1)	(2)	(3)	(4)	(5)
Municipal DPK-emigration	0.002***	0.002***	0.002***	0.010***	0.006***
	(0.001)	(0.000)	(0.001)	(0.003)	(0.002)
National DPK-emigration			0.006***		
			(0.001)		
Total municipal emigration					0.026***
					(0.008)
Patent class FE	Yes	No	No	Yes	Yes
Municipality FE	Yes	Yes	Yes	No	No
Municipality controls	No	No	No	Yes	Yes
Observations	212532	212532	212532	210129	210129
Mean dep. var.	0.023	0.023	0.023	0.023	0.023

Notes: 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Effects across patent classes

- Patent class-specific emigration increases innovation in those classes, even when controlling for municipality and patent class fixed effects.

- Omitting municipality FE, we see that overall emigration has a large positive effect on innovation. Sign of spillovers.

- Omitting patent class FE, we see that national-level emigration tied to a patent class also increases local innovation in that class. Sign of innovators keeping track of national demand.

Technological adoption

- We have documented large increases in innovative activity in different patent classes.
- How about adoption of new technology?

Technological change in agriculture

Dependent variable:	Workers per capita	Draft animals per arable land	Workers per draft animal	Workers per horse
	(1)	(2)	(3)	(4)
Emigrants 1867–1910	-0.032***	0.079***	-0.074**	-0.111**
	(0.010)	(0.027)	(0.030)	(0.050)
Region FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Market access controls	Yes	Yes	Yes	Yes
Observations	2370	2093	2086	2086
F-stat	20.69	22.58	22.70	22.70
Mean dep. var.	0.05	0.15	0.23	0.29

Notes: 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Technological change in industry

Dependent variable:	Workers per capita	Power per output value	Equity per worker	High-skill ratio
	(1)	(2)	(3)	(4)
Emigrants 1867–1900	0.017**	0.009***	1.005*	0.081**
	(0.009)	(0.003)	(0.532)	(0.039)
Region FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Market access controls	Yes	Yes	Yes	Yes
Observations	2376	2388	2375	2376
F-stat	15.16	14.62	15.16	15.16
Mean dep. var.	0.05	0.01	1.21	0.18

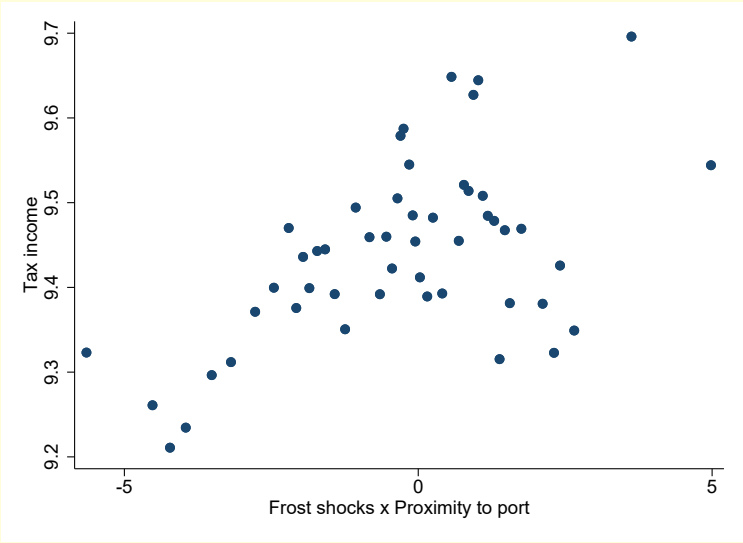
Notes: 2SLS regressions. Standard errors are clustered at the weather station level.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Effects across patent classes

- Fewer unskilled agricultural workers and more draft animals in agriculture. In particular, more horses, which were used with labor-saving machinery.

- More lowskilled industrial workers, higher capital share (as measured by power usage per value of output), higher equity in incorporated firms per non-agricultural worker, and higher ratio och high-to-low skilled non-agricultural workers.

Municipal tax income



Notes: Reduced-form effect of the instrument on municipal taxi income in 1900.

Wage growth within agriculture

Dependent variable:	Nominal wage growth		Real wage growth	
	(1)	(2)	(3)	(4)
Emigrants 1867–1914	0.516**	0.717***	0.684**	1.079***
	(0.203)	(0.221)	(0.271)	(0.296)
Controls	No	Yes	No	Yes
Observations	23	23	23	23
Mean dep. var.	2.66	2.66	3.62	3.62

Notes: OLS regressions. Robust standard errors. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Role of return flows from the US?

- Test for the importance of human and economic capital flows from the US: return migration.
  - Direct effects: return migrant inventors.
  - Indirect effects: spillovers at home.

- But, difficult to fully separate emigration from return migration.
  - Our IV for emigration has a positive effect on return migration.
  - Consistent with migrants returning to home municipality – at least to some extent.

- Start by looking at OLS:

Return Migration

Dependent variable:	Patents			Patent fees		
	(1)	(2)	(3)	(4)	(5)	(6)
Emigrants	0.262***		0.259***			0.368***
	(0.040)		(0.039)			(0.057)
Return migrants		0.080***	0.006	0.096**	0.096**	-0.010
		(0.025)	(0.018)	(0.035)	(0.035)	(0.028)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2388	2388	2388	2388	2388	2388
Mean dep. var. ymean	0.62	0.62	0.62	0.99	0.99	0.99

Notes: OLS regressions. Robust standard errors in parenthesis.
*** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Less influence from US

Dependent variable:	Return flow weighted patents					
	Returnee occupations			US style patents		
	(1)	(2)	(3)	(4)	(5)	(6)
Emigrants 1867–1914	-1.997**	-1.508**	-1.613**	-0.039*	-0.043*	-0.046**
	(0.884)	(0.710)	(0.641)	(0.021)	(0.022)	(0.021)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes
Market access controls	No	No	Yes	No	No	Yes
Observations	2376	2376	2376	2376	2376	2376
F-statistic	16.76	20.77	21.42	16.76	20.77	21.42
Mean dep. var.	-0.64	-0.64	-0.64	-0.02	-0.02	-0.02

Notes: OLS regressions.Standard errors are given in parentheses and are clustered at the weather station level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

Concluding remarks

- Mass migration affected technological change in sending locations.
  - Increased innovative activity and technological adoption.
- Evidence consistent with the “induced innovation hypothesis” within the agricultural sector (labor scarcity & increasing wages).
- In contrast, industrial sector benefits in terms of both innovative activity and employment.
- Little evidence for possible alternative mechanisms to explain our results (economic and human capital accumulation abroad).