Trade, Structural Transformation and Development: Evidence from Argentina 1869-1914

Pablo Fajgelbaum
Princeton University and NBER

Stephen J. Redding
Princeton University and NBER

Motivation

- Relationship between international trade and economic development is widely-debated in trade and development economics
  - To what extent does international trade promote structural transformation and economic development?
  - What is the spatial incidence of international trade shocks?
  - What role do internal trade costs play in the transmission of these international trade shocks?

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  - What is the spatial incidence of international trade shocks?
  - What role do internal trade costs play in the transmission of these international trade shocks?
- We provide new theory and evidence using Argentina's emergence into the global economy in the late-19th century
  - Reductions in internal and external transport costs from steam railroads and ships and new technologies such as refrigeration
  - Spatially-disaggregated data by region and sector from 1869-1914
  - Quantitative model that emphasizes the interaction between structural transformation across sectors and internal trade costs across regions

Main Findings

- Economic development involved major changes in the spatial and sectoral distribution of economic activity
  - Population density sharply decreasing in distance from leading ports
  - Gradient greater for urban population density and steepens over time
  - Causal impact of railroads on level and composition of economic activity

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- Develop a theoretical model to account for this reduced-form evidence that emphasizes a *spatial Balassa-Samuelson effect*
  - Locations with better access to world markets have higher population densities, higher urban population shares, higher relative prices of non-traded goods, and higher land prices relative to wages
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  - These locations specialize in most transport-cost sensitive traded goods
- Structurally estimate the model's parameters
- In counterfactuals, find substantial impacts of external and internal integration on economic development
  - Reductions in transatlantic freight rates from 1869 to 1914 raised Argentina's GDP, population, and welfare by 17.7%, 13.8%, and 7.1%
  - Construction of the railroad network increased GDP, population, and welfare by 12.8%, 9.4%, and 4.8%

Related Literature

- Quantitative spatial models
  - Redding and Sturm (2008), Ahlfeldt et al. (2015), Allen and Arkolakis (2014), Cosar and Fajgelbaum (2012), Desmet et al. (2018), Ramondo et al. (2016), Redding (2016), Monte, Redding and Rossi-Hansberg (2018), Caliendo et al. (2018), Fajgelbaum et al. (2019)
- Empirical literature on transportation infrastructure and the spatial distribution of economic activity
  - Banerjee et al. (2012), Baum Snow (2007), Donaldson (2017), Donaldson and Hornbeck (2016), Faber (2014), Michaels (2008), Duranton and Turner (2011, 2012, 2014), Redding and Turner (2015)
- Macro literature on structural transformation
  - Bustos, Caprettini and Ponticelli (2016), Caselli and Coleman (2001), Gollin et al. (2002), Matsuyama (1992), Ngai and Pissarides (2007), Herrendorf et al. (2013), Bustos, Garber and Ponticelli (2020)
- Historical literature on Argentine economic development
  - Adelman (1994), Berlinski, Galiani and Jaitman (2011), Cortes Conde (1993, 2015), Droller (2017), Perren (2006), Pérez (2017), Scobie (1971), Taylor (1992, 1994, 1998)

Outline

- Historical Background
- Data
- Reduced-form Evidence
- Theoretical model
- Structural Estimation
- Counterfactuals

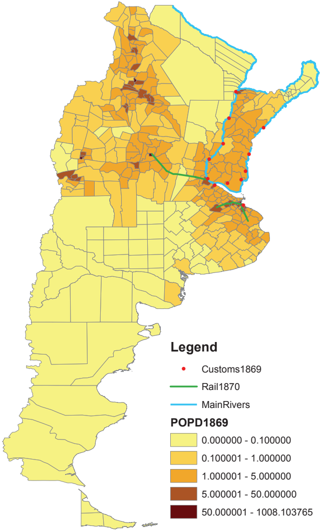
Historical Background

- During Spanish colonial rule, economic activity orientated towards the North-west, with official trade routines through Panama
- In response to encroaching Portuguese settlement, Viceroyalty of the Río de la Plata established in Buenos Aires in 1776
- Following local seizure of power in 1810 during Napoleonic Wars, opening of direct trade with third nations from Buenos Aires
- From this point onwards, Buenos Aires and its surrounding ports emerge as Argentina's leading trade hub
- With late-19th century reductions in internal and external trade costs, Argentina experienced one of the largest recorded export booms, with agriculture accounting for $> 99\%$ exports
- Rapid economic development from 1869 to 1914
  - Total population rose from 1.8 to 7.9 million
  - Share of employment in agriculture fell by 7 percentage points
  - Share of urban population rose by 20 percentage points
  - Argentina became the eighth richest country in the world by 1914

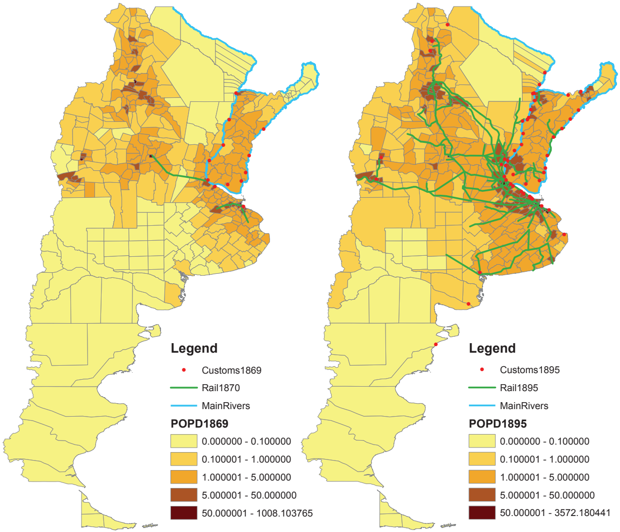
Data

- Population census data 1869, 1895 and 1914
  - 380 districts and 23 provinces based on constant (1895) boundaries
  - Total population, rural population (agriculture) and urban population (non-agriculture)
- Spatially-disaggregated data on agriculture for 1895 and 1914
  - Cultivated area for crops
  - Numbers of livestock
  - Number and value of agricultural machines
- Internal railroad data
  - Rail network 1869, 1895 and 1914
  - Location of railway stations
  - Quantities loaded at each railway station
- International trade data
  - Trade by disaggregated product and foreign country
  - Trade by disaggregated product and Argentinian customs
- Other geographical information systems (GIS) data

Population Density



Population Density



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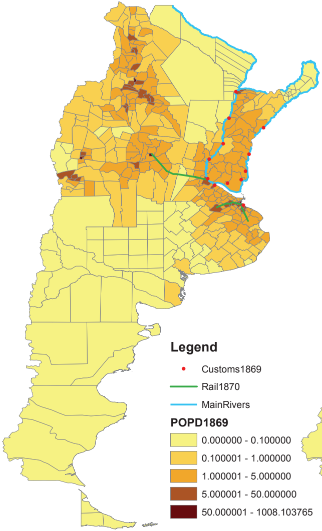

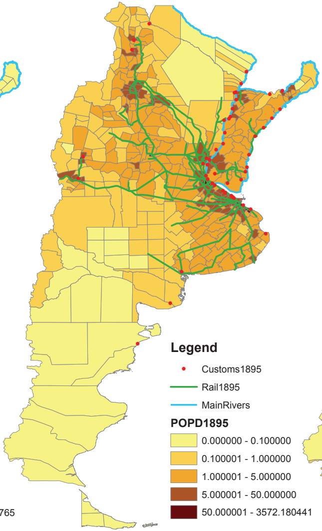

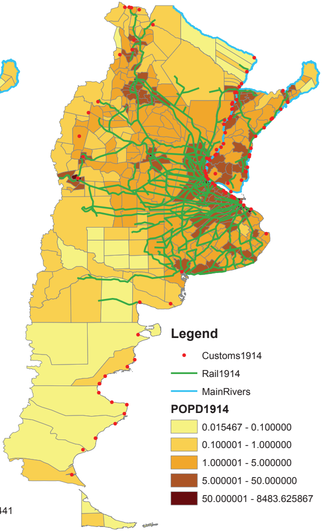

Reduced-Form Empirical Evidence

- Establish a number of stylized facts about patterns of economic development in Argentina that guide our theoretical model below

1. Steep gradient in population density with resect to distance to ports
2. This gradient is larger for urban than for rural population density

$$\ln Y_{it} = a_t + b_t \ln(\text{distport}_i) + u_{it}$$

- Consider top-four ports that account for more than 75 percent of export value throughout our sample period: Buenos Aires, La Plata, Rosario and Bahía Blanca

Geographical Access to World Markets

TABLE 1
Population Density, Structural Transformation, and Geographical Access to World Markets

	Log Population Density, 1869 (1)	Urban Population Share, 1869 (2)	Log Growth Population Density, 1869–1914 (3)	Change Urban Population Share, 1869–1914 (4)	Log Wage-Rental Ratio, 1895 (5)	Log Relative Price of Tradeables, 1895 (6)	Share Cereals Cultivated Area, 1914 (7)
Log distance top-four port	−.414***	−.046***	−.445***	−.059***	1.158***	.153***	−.085***
	(.089)	(.014)	(.048)	(.013)	(.168)	(.049)	(.019)
Observations	298	298	298	298	80	64	240
R^2	.085	.041	.238	.068	.420	.177	.118

Reduced-Form Empirical Evidence

3. Positive and statistically significant relationship between population density and railroad access

$$
\begin{aligned}
\Delta \ln Y_{i,1914-1869} = {} & a + c(\mathrm{rail}_{i,1914}) + d_1 \ln(\mathrm{area}_i) \\
& + d_2 \mathrm{lat}_i + d_3 \mathrm{long}_i + d_4 \ln Y_{i,1869} + u_i
\end{aligned}
$$

- We address the concern that railroads could have targeted interior regions that would have grown more rapidly even without railroads
- Instrument railroad access using the frequency a district is along
  - Least-cost paths to top-four ports
  - Spanish colonial postal routes

Population Density and Railroad Access

TABLE 2
POPULATION GROWTH AND RAILROAD ACCESS

	Log Population Growth, 1869–1914				
	(1)	(2)	(3)	(4)	(5)
Rail connection 1914	.650***	. . .	. . .	. . .	. . .
	(.092)				
Rail length 1914	. . .	.514***	.633***	.717***	.608***
		(.036)	(.073)	(.144)	(.073)
Latitude	−.070***	−.045***	−.035***	−.028	−.037***
	(.012)	(.011)	(.013)	(.017)	(.012)
Longitude	.041***	.044***	.043***	.042***	.043***
	(.012)	(.011)	(.011)	(.012)	(.011)
Log land area	−.016	−.204***	−.245***	−.274***	−.237***
	(.039)	(.036)	(.044)	(.061)	(.044)
Log population 1869	−.431***	−.393***	−.393***	−.394***	−.393***
	(.069)	(.058)	(.057)	(.057)	(.057)
Estimation	OLS	OLS	IV	IV	IV
Instruments	. . .	. . .	Both	Port	Colonial post
First-stage F-statistic	. . .	. . .	34.39	21.02	59.31
Overidentification test (p-value)	. . .	. . .	.465	. . .	. . .
Observations	298	298	298	298	298
R^2	.437	.574	. . .	. . .	. . .

Theoretical Model

- Economy comprises set of locations $\ell \in \mathcal{L}$ with land area $L(\ell)$
- Each location ℓ consists of a continuum of land plots $j \in [0, L(\ell)]$ with heterogeneous agricultural productivity
- Workers have one unit of labor and are mobile across locations

$$\sum_{\ell \in \mathcal{L}} L(\ell) n(\ell) = N.$$

- Common component of utility defined over *tradables* & *non-tradables*

$$u(\ell) = \left[\beta_T^{\frac{1}{\sigma}} C_T(\ell)^{\frac{\sigma-1}{\sigma}} + (1-\beta_T)^{\frac{1}{\sigma}} C_N(\ell)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}.$$

- Tradables consumption defined over composite *manufacturing* good and set of *agricultural goods* $g = 1, \ldots, G$

$$E_T(\ell) = E_T\left(\{P_g(\ell)\}_{g=1}^{G}, P_M(\ell) \right).$$

- Trade costs $\{\delta_M(\ell, \ell^*), \delta_g(\ell, \ell^*)\}$ to trade hub

Labor Markets

- Workers draw idiosyncratic preferences for locations
  - First, observe idiosyncratic tastes for Argentina and ROW
  - Second, if choose to live in Argentina, observe idiosyncratic tastes for each location within Argentina
- Supply of workers choosing to live in Argentina ($N^S(u^*)$) is:

$$N^S(u^*) = \frac{1}{1 + \left(\frac{u^{RW}}{u^*}\right)^{\varepsilon^{INT}}} N^W, \qquad \varepsilon^{INT} > 1$$

- Conditional on choosing to live in Argentina, the supply of workers that decide to live in location ℓ ($N(\ell)$) is given by:

$$N(\ell) = \left(\frac{u(\ell)}{u^*}\right)^{\varepsilon} N^S(u^*), \qquad \varepsilon > 1$$

- Expected utility from living in Argentina (u^*) is:

$$u^* = \left[\sum_{\ell \in \mathcal{L}} u(\ell)^{\varepsilon}\right]^{\frac{1}{\varepsilon}}$$

Production Technology

- Output per unit of land in each sector is:

$$
\begin{aligned}
q_N(\ell) &= \kappa_N z_N(\ell) n_N(\ell)^{1-\alpha_N} \\
q_M(\ell) &= \kappa_M z_M(\ell) n_M(\ell)^{1-\alpha_M} \\
q_{g,j}(\ell) &= \kappa_A z_{g,j}(\ell) n_{g,j}(\ell)^{1-\alpha_A}
\end{aligned}
$$

- Each land plot is owned by a landowner that decides whether to allocate it to agriculture, manufacturing or non-tradables
- If the land plot is allocated to agriculture, the landowner learns its productivity draws for each agricultural good $\{z_{g,j}(\ell)\}_{g=1}^{G}$

$$F_{g,\ell}(z) = e^{-T_g(\ell) z^{\theta(\ell)}},$$

- $T_g(\ell)$ controls average productivity in agriculture
- $\theta(\ell)$ controls dispersion of agricultural productivity

Profit Maximization Non-Agriculture

- When a land plot is used in manufacturing or non-tradables, land rents are:

$$r_i(\ell) = \max_{n_i(\ell)} \{P_i q_i(n_i(\ell)) - w(\ell) n_i(\ell)\} = \frac{w(\ell)}{\omega_i(\ell)},$$

- Equilibrium wage-rental ratio when there is production in sector i is:

$$\omega_i(\ell) = \left(\frac{w(\ell)}{z_i(\ell) P_i(\ell)} \right)^{\frac{1}{\alpha_i}},$$

- Equilibrium labor demands and revenue per unit of land are:

$$\begin{aligned} n_i(\ell) &= \tfrac{1-\alpha_i}{\alpha_i} \tfrac{1}{\omega_i(\ell)}, \\ \pi_i(\ell) &= P_i(\ell) q_i(\ell) \quad = \tfrac{r_i(\ell)}{\alpha_i}. \end{aligned}$$

Aggregation in Agriculture

- When land allocated to agriculture, expected land rents are

$$r_A(\ell) = \mathbb{E}\left[r_j(\ell)\right],$$

$$r_j = \max_g \{r_{g,j}(\ell)\},$$

$$r_{g,j}(\ell) = \max_{n_{g,j}(\ell)} \left\{P(z;\ell)q_{g,j}(\ell) - w(\ell)n_{g,j}(\ell)\right\}.$$

- Aggregate measure of agricultural productivity

$$z_A(\ell) = \Gamma\left(\frac{\alpha_A\theta - 1}{\alpha_A\theta}\right)^{\alpha_A}\left[\sum_{g=1}^{G} T_g(\ell)\, P_g(\ell)^{\theta}\right]^{1/\theta},$$

- Equilibrium expected land rents and labor demand and revenue per unit of land area are:

$$\begin{aligned} r_A(\ell) &= \mathbb{E}\left[r_j(\ell)\right] &= w(\ell)\left(\tfrac{z_A(\ell)}{w(\ell)}\right)^{1/\alpha_A}, \\ n_A(\ell) &= \mathbb{E}\left[n_j(\ell)\right] &= \tfrac{1-\alpha_A}{\alpha_A}\left(\tfrac{z_A(\ell)}{w(\ell)}\right)^{1/\alpha_A}, \end{aligned}$$

General Equilibrium

Definition A general equilibrium consists of an expected utility u^*; a total population N; allocations of population density $n(\ell)$, land $\{L_i(\ell)\}_{i=N,M,A}$, and employment density $\{n_i(\ell)\}_{i=N,M,A}$; wages $w(\ell)$; land rents $r(\ell)$; and prices $\{P_g(\ell)\}_{g=1}^{G}$, $P_M(\ell)$, $P_N(\ell)$ for all $\ell \in \mathcal{L}$

- Workers maximize utility and choose their location optimally
- Producers maximize profits and land is allocated optimally
- Land market clears in each location
- Labor market clears in each location
- Non-tradable goods market clears in each location
- Tradeable goods prices are determined by no-arbitrage
- Expected utility adjusts to clear the labor market for whole economy

Specialization Pattern

- Specialization pattern and land rents determined by ($P_A = 1$)

$$\begin{aligned} \omega(\ell) &= \min_{i=A,M,N} \{\omega_i(\ell)\}, \\ \omega_i(\ell) &= \left[\frac{w(\ell)}{z_i(\ell) P_i(\ell)} \right]^{\frac{1}{\alpha_i}}, \end{aligned}$$

- Population mobility

$$\left[\beta_T \left(\frac{P_i(\ell)}{E_T(\ell)} z_i(\ell) \omega_i(\ell)^{\alpha_i} \right)^{\sigma-1} + (1-\beta_T) \left(z_N(\ell) \omega_i(\ell)^{\alpha_N} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}} = u(\ell).$$

$$N(\ell) = \left(\frac{u(\ell)}{u^*} \right)^{\varepsilon} N^S(u^*)$$

- Land shares for disaggregated agricultural goods

$$l_g(\ell) = \Pr\left(g = \arg\min_{g'} \left\{ \omega_{g',j}(\ell) \right\} \right) = \frac{T_g(\ell) P_g(\ell)^{\theta(\ell)}}{\sum_{g=1}^{G} T_g(\ell) P_g(\ell)^{\theta(\ell)}}.$$

Spatial Balassa-Samuelson Effect

Proposition

*(**Spatial Balassa-Samuelson Effect**) Assume that traded and non-traded goods are complements ($\sigma < 1$), agriculture is land-intensive ($\alpha_N < \alpha_A$), and population is mobile within Argentina (ε sufficiently large). Under these assumptions, low trade-cost locations (locations ℓ with lower transport costs $\left\{\delta_g\left(\ell, \ell^*\right)\right\}_{g=1}^{G}, \delta_M\left(\ell, \ell^*\right)$) have **(i)** higher adjusted-agricultural productivity ($\widetilde{z}_A\left(\ell\right)$), **(ii)** higher relative prices of non-traded goods (lower $E_T\left(\ell\right)/E\left(\ell\right)$), **(iii)** higher population density ($n\left(\ell\right)$), **(iv)** lower agricultural employment shares ($\nu_A\left(\ell\right)$), and **(v)** lower wage-rental ratios.*

- Lower transport costs make a location more attractive for producing and consuming tradeables, thereby raising population density ($n(\ell)\uparrow$)
- This higher population density ($n(\ell)\uparrow$) is absorbed through both
  - An expansion in the labor-intensive non-traded sector, which requires a higher relative price for non-traded goods ($E_N(\ell)/E(\ell)\uparrow$), given inelastic demand between sectors ($0 < \sigma < 1$)
  - A switch to more more labor-intensive techniques in both sectors, which requires a lower wage-rental ratio ($\omega(\ell) = w(\ell)/r(\ell)\downarrow$)

Production Cost Parameters (Step 1)

- Estimate (α_A, α_N) using model's predictions for wage-rental ratio

$$\omega(\ell) = \frac{w(\ell)}{r(\ell)} = \frac{(1-\alpha_A)(1-\alpha_N)}{\alpha_N(1-\alpha_A) + (\alpha_A - \alpha_N)\nu_A(\ell)} \frac{1}{n(\ell)}$$

- Consistent with the nontraded sector being labor intensive, we estimate labor shares of $(1-\alpha_A) = 0.39$ and $(1-\alpha_N) = 0.58$

Demand Parameters (Step 2)

- Estimate elasticity of substitution (σ) and weight of tradeables (β_T) using relationship in the model between tradeables expenditure share ($s_T(\ell)$) and relative tradeables price index ($E_T(\ell)/E(\ell)$)

$$\begin{aligned}\ln s_T(\ell) &= \ln\left[\frac{(1-\alpha_N)\,\nu_A(\ell)}{(1-\alpha_A)+(\alpha_A-\alpha_N)\,\nu_A(\ell)}\right]\\ &= \kappa_0+\kappa_1\ln\left(\frac{E_T(\ell)}{E(\ell)}\right)+\ln h_T(\ell)\end{aligned}$$

- From spatial Balassa-Samuelson effect, transport costs to world markets are a valid instrument for the relative tradeables price index
- Instrument the relative tradeables price index using a measure of travel time to the nearest top-four port based on colonial postal routes

Demand Parameters (Step 2)

TABLE 3
TRADEABLES EXPENDITURE SHARE ($s_{T\ell}$) AND RELATIVE TRADEABLES PRICE INDEX ($E_{T\ell}/E_\ell$)

	LOG SHARE OF TRADEABLES IN EXPENDITURE ($s_{T\ell}$)		LOG RELATIVE PRICE OF TRADEABLES ($E_{T\ell}/E_\ell$)
	(1)	(2)	(3)
Regression constant (κ_0)	−.293***	−.263***	−3.576***
	(.042)	(.055)	(.535)
Log relative price of tradeables ($E_{T\ell}/E_\ell$) (κ_1)	.350***	.506*	. . .
	(.124)	(.272)	
Log IV travel time top-four port	. . .	. . .	.255***
			(.041)
Implied σ	.650	.494	. . .
Implied β_T	.746	.768	. . .
Estimation	OLS	IV (second stage)	OLS (first stage)
Observations	63	63	63
R^2	.11	. . .	.381
First-stage F-statistic	. . .	. . .	38.38

Population Mobility Parameters (Step 3)

- Estimate domestic population mobility parameter (ε) using domestic population mobility condition

$$\ln n(\ell) = \kappa_n + \frac{\varepsilon}{1+\varepsilon} \ln \left[\frac{r(\ell)}{\left[\alpha_N (1-\alpha_A) + (\alpha_A - \alpha_N)\, \nu_A(\ell)\right] E(\ell)} \right] + h_n(\ell)$$

- Instrument real income on RHS using a measure of travel time to the nearest top-four port based on colonial postal routes
- Estimate the international population mobility parameter (ε^{INT}) using the international population mobility condition
  - Relates Argentina's share of the world population (N_t / N_t^W) and relative expected utility (u_t^* / u_t^{RW})
  - Proxy relative expected utility using relative real GDP per capita
- Obtain estimates of $\varepsilon = 4.73$ and $\varepsilon^{INT} = 2.02$

Demand Parameters (Step 3)

TABLE 4
POPULATION DENSITY AND REAL INCOME

	Log Population Density (n_ℓ)		Log Real Income
	(1)	(2)	(3)
Log real income	.738***	.826***	. . .
	(.118)	(.153)	
Log IV travel time top-four port	. . .	. . .	−1.078***
			(.163)
Implied preference dispersion (ε)	2.811	4.733	. . .
Estimation	OLS	IV (second stage)	OLS (first stage)
Observations	63	63	63
R^2	.52	. . .	.39
First-stage F-statistic	. . .	. . .	43.69

Expected Utility (Step 4)

- Calibrate expected utility in Argentina in each year (u_t^*) such that the model is consistent with GDP in 1914 prices (Cortes Conde 1994)

$$Y_t = \sum_{\ell \in \mathcal{L}} \frac{y_t(\ell) L(\ell)}{E_t(\ell)} = \frac{u_t^*}{N_t^{\frac{1}{\varepsilon}}} \sum_{\ell \in \mathcal{L}} \frac{(1-\alpha_A) + (\alpha_A - \alpha_N) \nu_{At}(\ell)}{(1-\alpha_A)(1-\alpha_N)} L(\ell)^{\frac{\epsilon+1}{\epsilon}} n_t(\ell)^{\frac{\varepsilon+1}{\varepsilon}}$$

- where $y_t(\ell) = w_t(\ell)\left[n_t(\ell) + 1/\omega_t(\ell)\right]$ is nominal income per unit of land and $E_t(\ell)$ is overall price index

Model Inversion (Step 5)

- Given parameter estimates, $(\alpha_A, \alpha_N, \sigma, \beta_T, \varepsilon, \varepsilon^{INT}, u_t^*, u_t^{RW})$, recover unique values of location characteristics $(\widetilde{z}_{At}(\ell), z_{Nt}(\ell), n_t(\ell), \nu_{At}(\ell))$ consistent with the data being an equilibrium of the model

$$\frac{E_{Tt}(\ell)}{E_t(\ell)} = \left(\frac{1}{\beta_T} \frac{(1-\alpha_N)\,\nu_{At}(\ell)}{(1-\alpha_A) + (\alpha_A - \alpha_N)\,\nu_{At}(\ell)} \right)^{\frac{1}{1-\sigma}}$$

$$\omega(\ell) = \frac{w(\ell)}{r(\ell)} = \frac{(1-\alpha_A)(1-\alpha_N)}{\alpha_N(1-\alpha_A) + (\alpha_A - \alpha_N)\,\nu_A(\ell)} \frac{1}{n(\ell)}$$

$$\widetilde{z}_{At}(\ell) = \frac{z_{At}(\ell)}{E_{Tt}(\ell)} = \frac{u_t^*}{\omega_t(\ell)^{\alpha_A}} \left(\frac{N_t(\ell)}{N_t} \right)^{1/\varepsilon} \frac{1}{(E_{Tt}(\ell)/E_t(\ell))},$$

$$z_{Nt}(\ell) = \frac{u_t^*}{\omega_t(\ell)^{\alpha_N}} \left(\frac{N_t(\ell)}{N_t} \right)^{1/\varepsilon} \left(\frac{1-\beta_T}{1-\beta_T \left(\frac{E_{Tt}(\ell)}{E_t(\ell)} \right)^{1-\sigma}} \right)^{\frac{1}{1-\sigma}}$$

Land Shares (Step 6)

1. Estimate impact of railroad network on relative technology-adjusted prices for disaggregated agricultural goods in 1914

$$l_{gt}(\ell) = \mu_{gt}\tau_t(\ell, \ell^*)^{\phi_g}\, lat(\ell)^{\kappa_g}\, long(\ell)^{\vartheta_g}\, h_{gt}(\ell)$$

2. Use these estimates and the observed change in the railroad network going backwards in time to 1895 and 1869 to estimate the change in technology-adjusted prices at Argentina's trade hub and hence the change in aggregate agricultural productivity ($\widehat{z}_{At}(\ell)$).
3. Use predictions for changes in agricultural productivity ($\widehat{z}_{At}(\ell)$) and solutions for changes in adjusted agricultural productivity ($\widehat{\widetilde{z}}_{At}(\ell)$) from Step 5 to estimate the productivity dispersion parameter (θ)

$$\ln \widehat{z}_{A\chi}(\ell) = \kappa_A + \frac{1}{\theta}\ln\left[\sum_{g=1}^{G} l_{gt}(\ell)\,\widehat{\mu}_{g\chi}\widehat{\tau}_{\chi}(\ell, \ell^*)^{\phi_g}\right]$$

4. Overidentification checks on model predictions using data on railroad shipments and the value of agricultural machines

Agricultural Specialization (Step 6)

TABLE 5
Agricultural Specialization and the Transport Network in 1914

	Share of Agricultural Land Area ($s_{g\ell}$)	
	(1)	(2)
Travel time top-four port:		
Cereal cultivation	−.421***	−.253***
	(.083)	(.082)
Other crop cultivation	.088	.093
	(.262)	(.286)
Cattle grazing (purebred/mixed breed)	−.355***	−.340***
	(.059)	(.063)
Cattle grazing (native breed)	.473***	.298**
	(.121)	(.145)
Sheep grazing (purebred/mixed breed)	−.106	−.030
	(.125)	(.121)
Sheep grazing (native breed)	1.544***	1.412***
	(.268)	(.302)
Latitude and longitude	Yes	Yes
Estimation	PPML	IV PPML
Observations	380	380
First-stage F-statistic	. . .	3,017.24

Agricultural Productivity (Step 6)

TABLE 6
ESTIMATES FOR THE LOG TRADEABLES PRICE INDEX ($E_{T\ell}$)
AND PRODUCTIVITY DISPERSION PARAMETER (θ)

	Log Tradeables Price Index ($E_{T\ell}$)		Log Growth of Adjusted Agricultural Productivity Scaled by the Tradeables Price Index
	(1)	(2)	(3)
Log travel time top-four port	.063**	.061***	...
	(.025)	(.023)	
Log agricultural productivity predicted by land shares	...	...	.315***
			(.062)
Implied productivity dispersion parameter (θ)	...	...	3.176
Latitude and longitude	Yes	Yes	...
Estimation	OLS	IV	OLS
First-stage F-statistic	...	129.83	...
Observations	63	63	93
R^2	.33	...	.24

Counterfactuals

- Starting from data in 1914, reverse external integration (raise transatlantic freight rates) and reverse internal integration (remove the railroad network), going backwards in time to year 1869
- Use property that $(\widetilde{z}_{At}(\ell))$, $z_{Nt}(\ell)$, N_t^W, u_t^{RW}) are sufficient statistics for all aggregate variables, including $(n_t(\ell), \nu_{At}(\ell))$
  - Make assumptions about external and internal integration, which determine the sufficient statistics $\{\widetilde{z}_{At}(\ell), z_{Nt}(\ell), N_t^W, u_t^{RW}\}$.
  - Second, given these four sufficient statistics, solve for the counterfactual values of all aggregate variables of the model $\{n_t(\ell), \nu_{At}(\ell), \omega_t(\ell), E_{Tt}(\ell), E_t(\ell)\}$
- First, report counterfactuals in which directly change the aggregate sufficient statistics $\{\widetilde{z}_{At}(\ell), z_{Nt}(\ell), N_t^W, u_t^{RW}\}$
- Second, directly examine the impact of external and internal integration by changing transatlantic freight rates, travel times based on the construction of the railroad network, or both

Counterfactuals

TABLE 7
COUNTERFACTUAL PREDICTIONS FOR REAL GDP, TOTAL POPULATION, AND EXPECTED UTILITY IN ARGENTINA

Row	Counterfactual Exercise	Real GDP, 1869/1914	Total Population, 1869/1914	Expected Utility, 1869/1914
	A. Observed Data			
1	All sufficient statistics back to 1869	.136	.267	.517
	B. Adjusted Agricultural Productivity			
2	Adjusted agricultural productivity ($\tilde{z}_{A\ell t}$) back to 1869	.338	.437	.663
	C. External and Internal Integration			
3	Agricultural productivity ($z_{A\ell t}$) back to 1869	.660	.747	.865
4	Transatlantic freights back to 1869	.823	.862	.929
5	Railroad network back to 1869	.872	.906	.952
6	Transatlantic freights and railroad back to 1869	.720	.782	.885

Robustness Checks

- Allow for endogenous changes in the international terms of trade in response to changes in economic activity within Argentina
- Allow for endogenous productivity because of agglomeration forces in both the agricultural and non-traded sectors
- Allow for non-homothetic CES preferences

Conclusions

- We provide new theory and evidence on economic development and international trade from 19th-century Argentina
- Reduced-form evidence on patterns of economic development
  - Population density sharply decreasing in distance from leading ports
  - Gradient greater for urban population density and steepens over time
  - Causal impact of railroads on level and composition of economic activity
- Develop a theoretical model to account for this reduced-form evidence that emphasizes a *spatial Balassa-Samuelson effect*
  - Locations with better access to world markets have higher population densities, higher urban population shares, higher relative prices of non-traded goods, and higher land prices relative to wages
  - These locations specialize in most transport-cost sensitive traded goods
- In counterfactuals, find substantial impacts of external and internal integration on economic development
  - Reductions in transatlantic freight rates from 1869 to 1914 raised Argentina's GDP, population, and welfare by 17.7%, 13.8%, and 7.1%
  - Construction of the railroad network increased GDP, population, and welfare by 12.8%, 9.4%, and 4.8%

Thank You