The Distributional Consequences of Trade: Evidence from the Grain Invasion

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- Classic insight from international economics is that aggregate welfare gains are combined with winners and losers from trade.
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  - Urban workers / manufacturers versus rural aristocracy
- We provide evidence on distributional consequences across different geographical areas within England and Wales
  - New, spatially-disaggregated data from 1801-1901
  - Exogenous exposure measure based on agroclimatic conditions
  - Quantitative spatial model to rationalize our empirical findings and evaluate the aggregate economic impact of the Grain Invasion

Main Findings

- Key advantage of empirical setting is the difference in agroclimatic conditions between Western and Eastern parts of England and Wales
  - Warm ocean current of North Atlantic Drift and prevailing SW winds
  - Western areas have greater cloud cover, more precipitation and lower average temperatures, and also more mountainous
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- Substantial estimated treatment effects of the Grain Invasion on high-wheat suitability regions
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- Develop a quantitative spatial model to evaluate aggregate effects and income distributional consequences
  - Control for other determinants of spatial distribution economic activity
  - Use the model to undertake counterfactuals for the Grain Invasion
  - Find modest aggregate welfare gains and larger income distributional consequences (land rent changes from -10 to 10 percent)

Related Literature

- Distributional consequences of international trade
  - Stolper & Samuelson (1941), Jones (1971), Mussa (1974)
- Urbanization and structural transformation
  - Matsuyama (1992), Uy et al. (2013), Gollin & Rogerson (2014), Herrendorf et al. (2014), Bustos et al. (2016, 2020), Gollin et al. (2016), Sotelo (2020), Fajgelbaum & Redding (2022), Farrokhi & Pellegrina (2023), Eckert & Peters (2024)
- Local labor market effects of international trade shocks
  - Topalova (2010), Autor et al. (2013, 2016, 2020), Kovak (2013), Kovak & Dix-Carneiro (2015), Feenstra (2019), Pierce & Schott (2020), Eriksson et al. (2020)
- Quantitative spatial models
  - Redding & Sturm (2008), Allen & Arkolakis (2014, 2022), Desmet & Rossi-Hansberg (2014), Redding (2016), Redding & Rossi-Hansberg (2017), Desmet et al. (2018), Caliendo et al. (2018), Galle et al. (2018), Allen & Donaldson (2018), Monte et al. (2018), Caliendo et al. (2019), Fajgelbaum et al. (2019), Kleinman et al. (2023), Bilal (2024), Bilal & Rossi-Hansberg (2024), Kleinman (2024)
- Economic history of the corn laws, agricultural depression, industrial revolution, and decline of aristocracy in 19th-century Britain
  - Graham (1892), Nicholson (1904), Barnes (1930), Irwin (1989), Williamson (1990), O'Rourke (1997), Taylor (1999), Clark (2002), Schonhardt-Bailey (2006), Sharp (2009), Cannadine (2019), Caprettini & Voth (2019), Irwin & Chepeliev (2020)

Outline

- Historical Background
- Data
- Motivating Evidence
- Theoretical Model
- Quantitative Evidence

Historical Background

- Origins of the corn laws date back to laws of 1463 and 1670
  - Sliding scale of import duties that were part of regulations to stabilize the price of bread as the main source of sustenance
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- Following American Civil War of 1861-65, new transport technologies of steamship and railroad led to the new-world Grain Invasion
  - Repeal ensured that British markets remain open to Grain Invasion
  - "Great agricultural depression" after 1870

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Data

- Parish-level Population Census data for England and Wales
  - Around 11,000 parishes, aggregated into poor law unions and counties
  - Population by residence every census decade from 1801-1901
  - Employment by occupation from 1851 onwards
- Individual-level population census data
  - Name match individuals across population census waves (migration)
  - Data for 1851, 1861 and census decades from 1881-1901
- Rateable value data
  - Digitized and geolocated rateable value data by parish from 1815-1896
  - Market rental value of land and buildings for property taxation purposes
- Agricultural land use, farm prices, and imports of wheat
- Global Agro-Ecological Zones (GAEZ) crop suitability, endowments of other natural resources (e.g. coal and iron), urban & rural status etc

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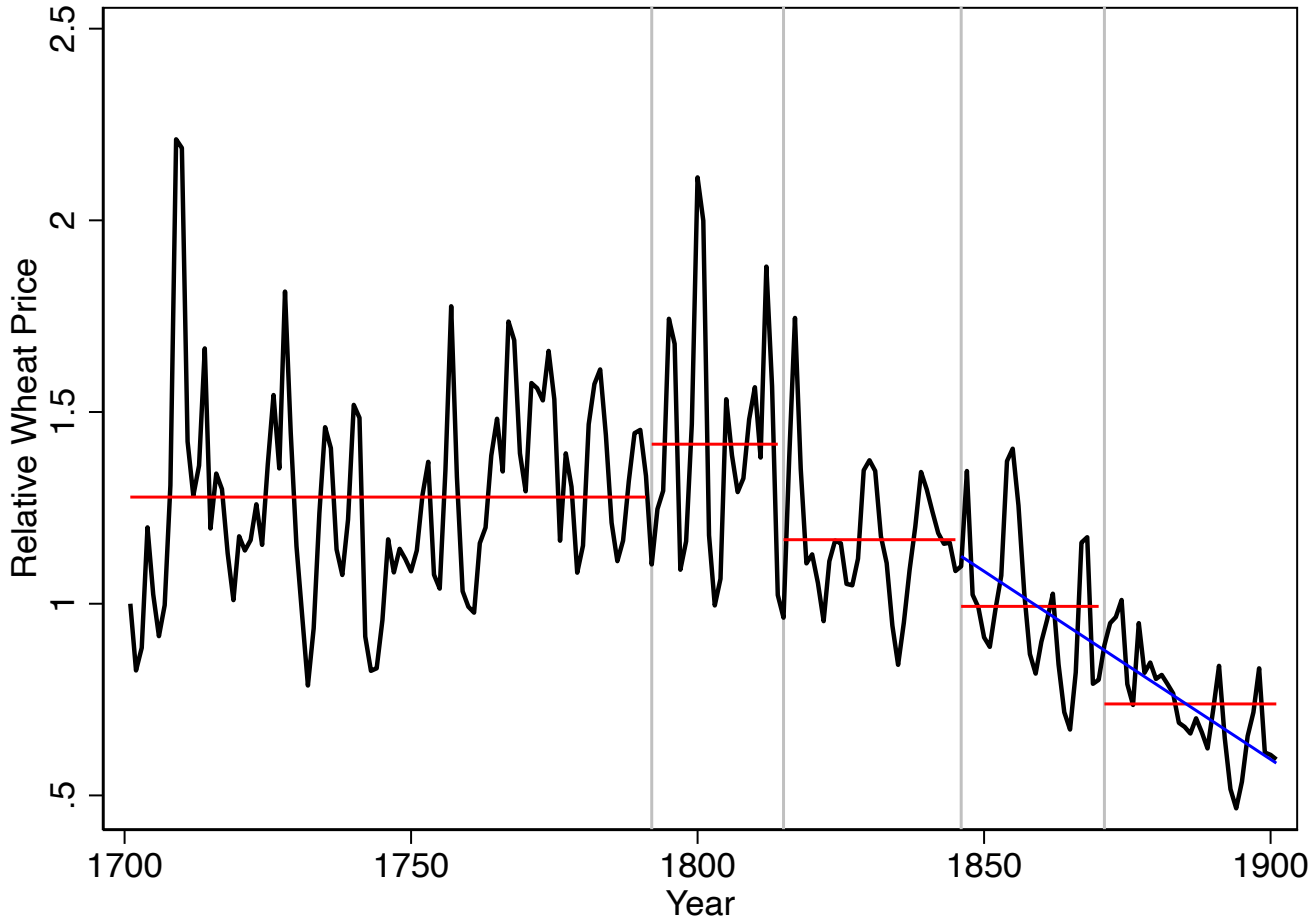
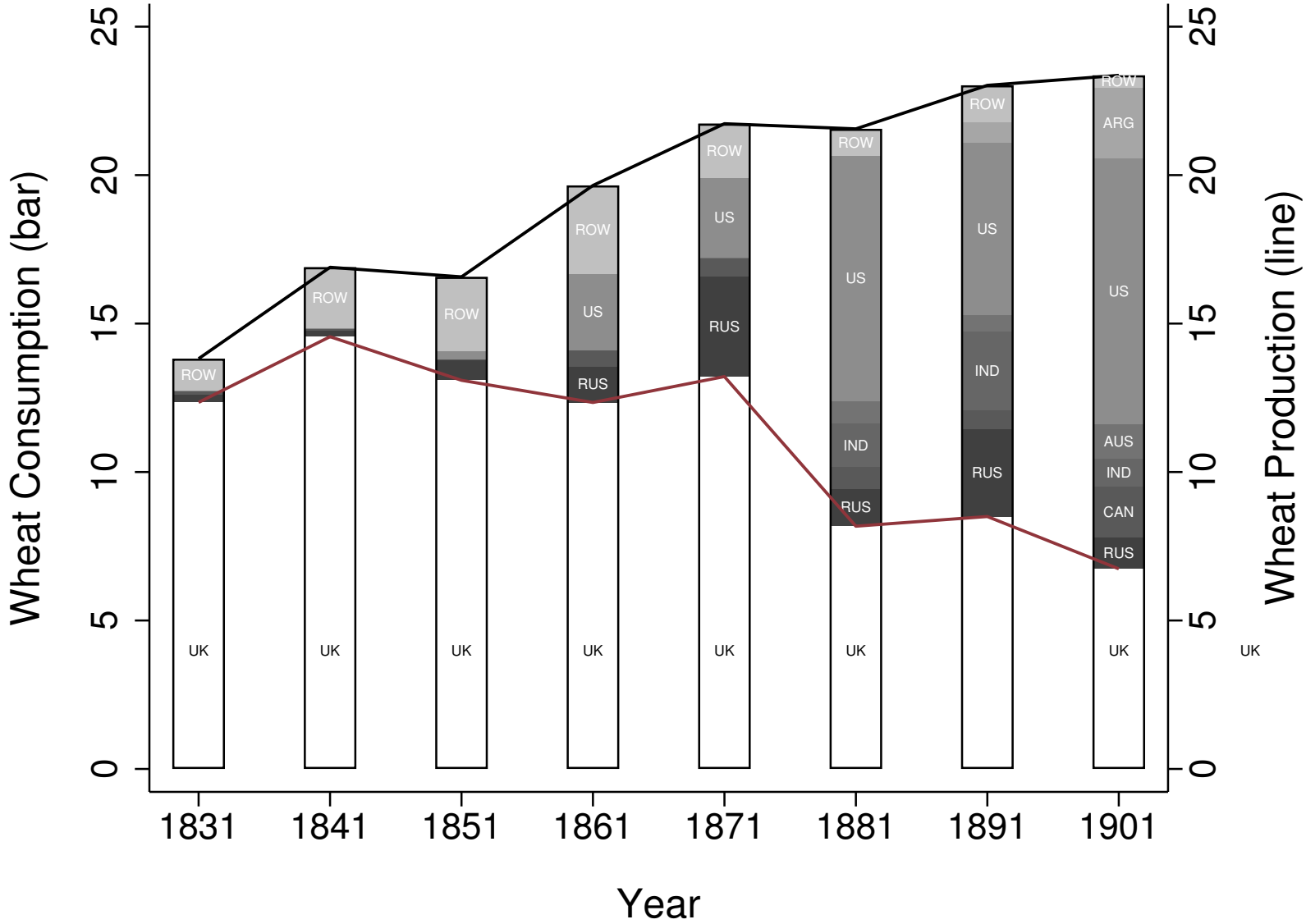
Corn Laws & Grain Invasion

Relative Wheat / Pastoral Prices



- Price ratios relative to pre-1792 period: 1792-1815 = 1.11; 1815-1846 = 0.91; 1846-1871 = 0.78; post-1871 = 0.58
- Gregory Clark: Price History of English Agriculture

UK Consumption, Production and Imports of Wheat



Wheat Suitability

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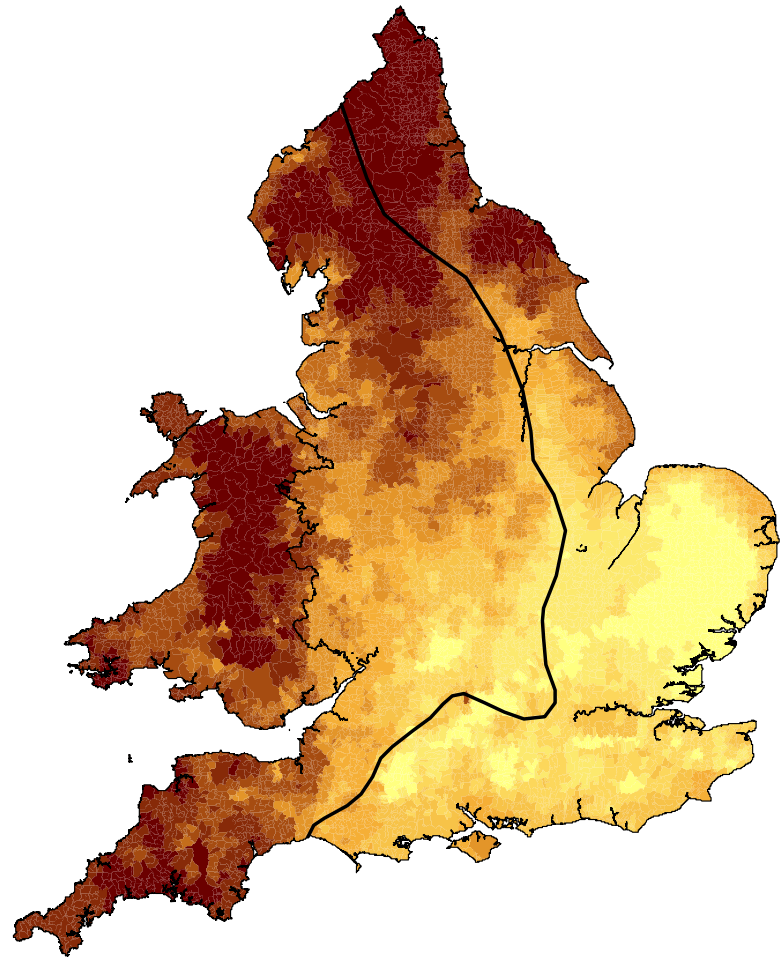
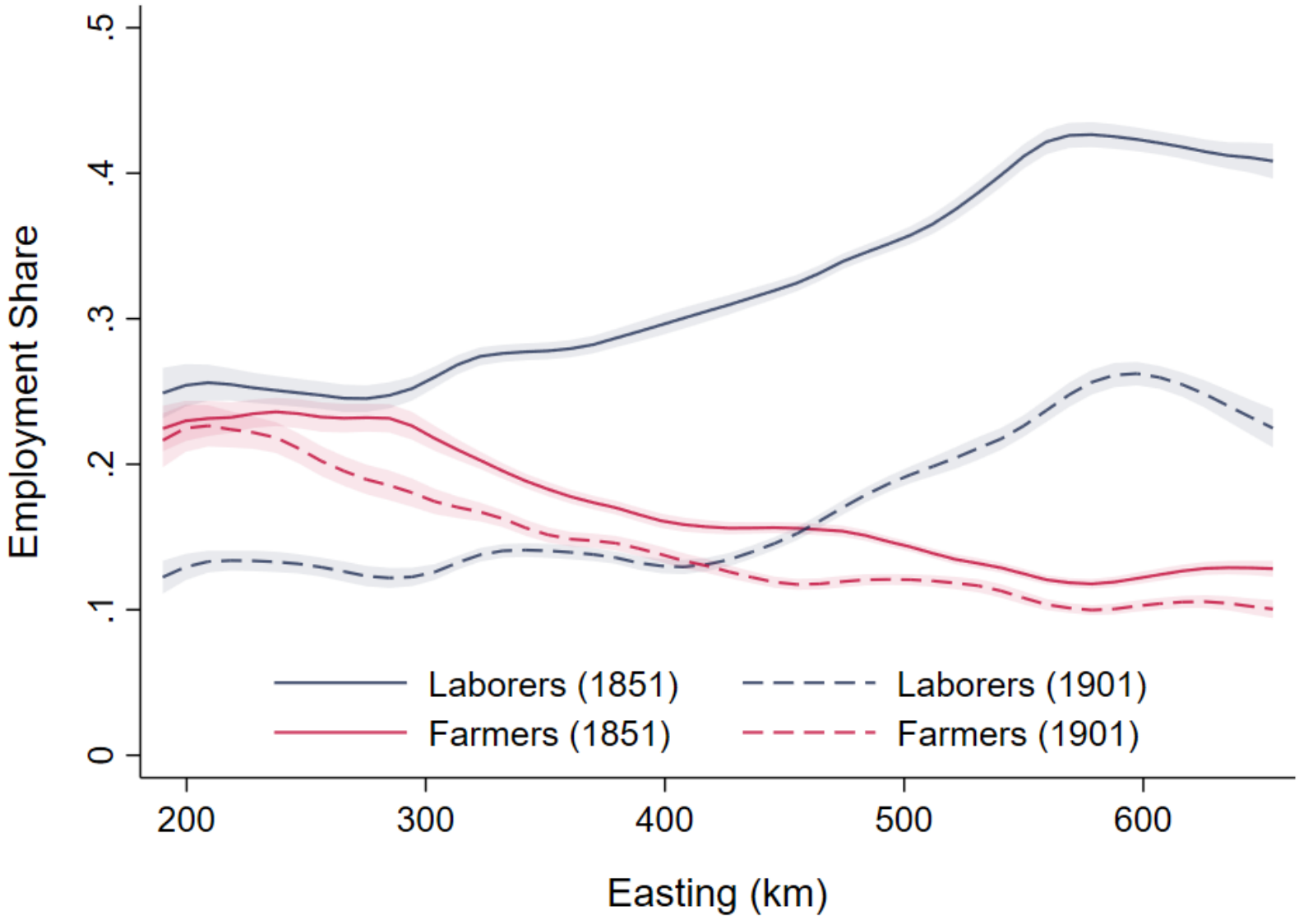
(a) Caird (1852)



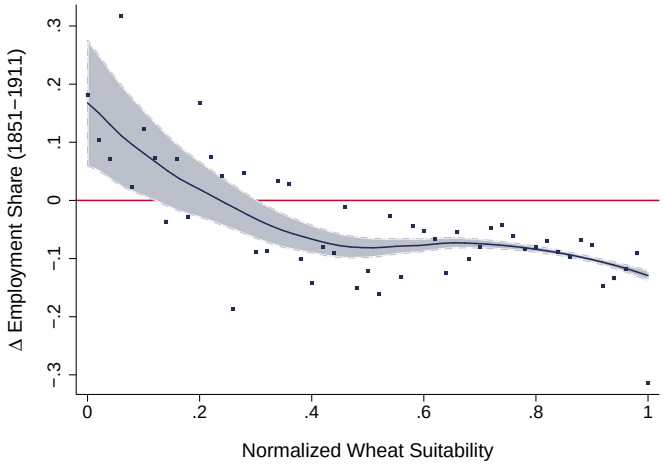
(b) Wheat Suitability (UN GAEZ)

Structural Transformation

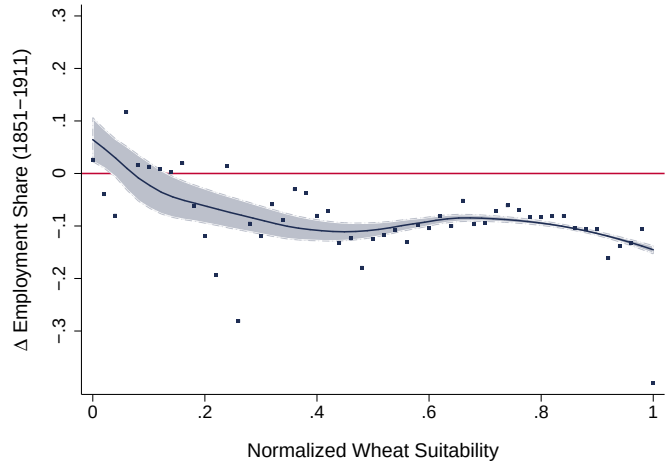
Laborers and Farmers 1851 & 1901



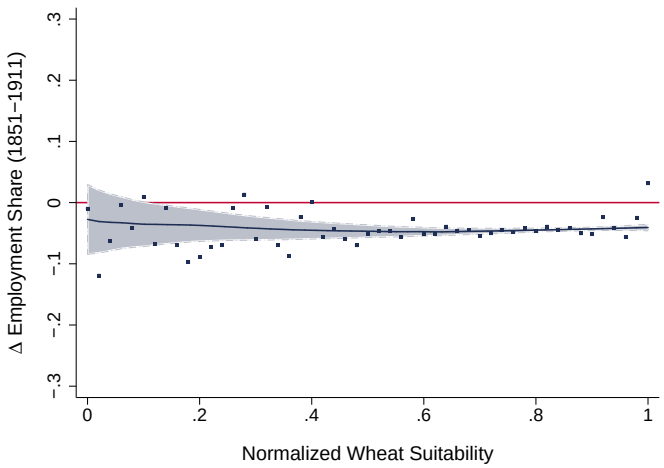
Change in Employment Shares



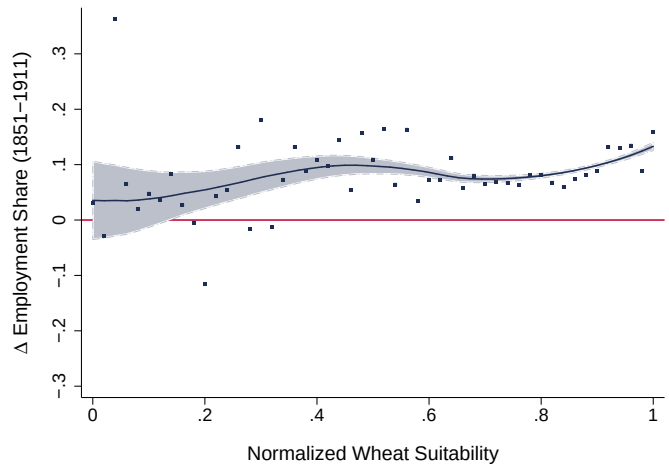
(a) Agriculture



(b) Agricultural Laborers



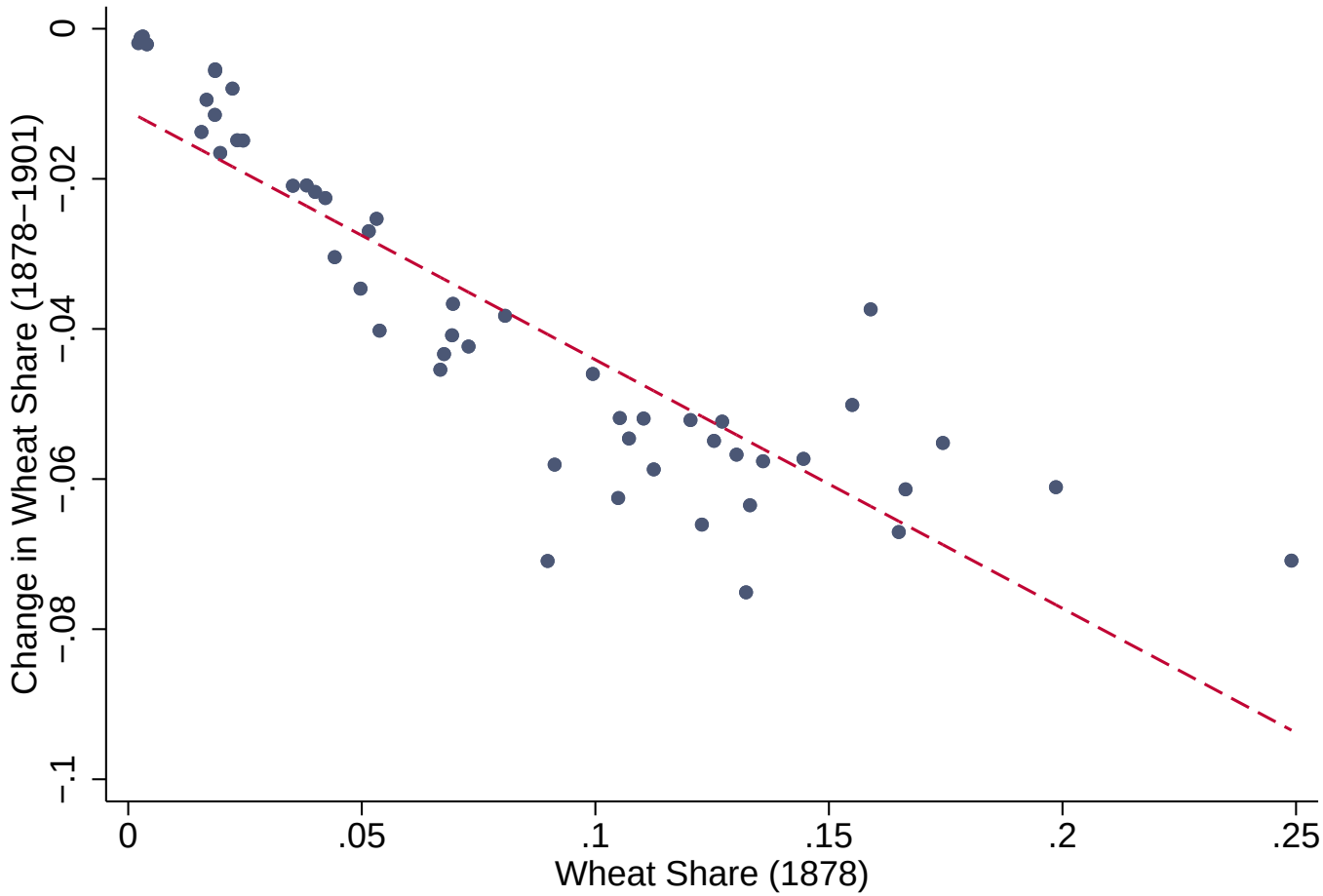
(c) Manufacturing



(d) Services

Arable Land Reallocation Away from Wheat

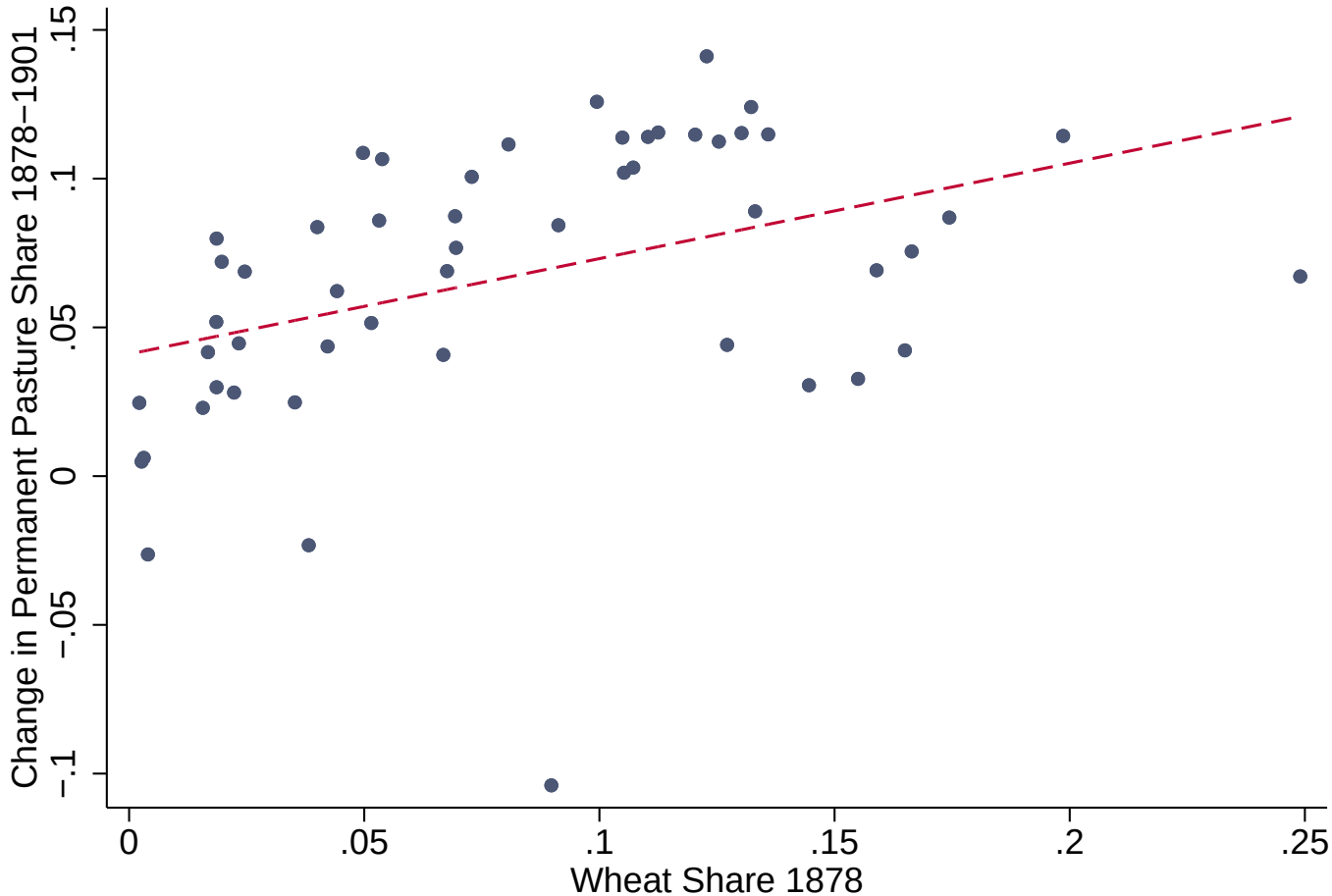
- County data from the agricultural census from the 1870s onwards



Note: Slope coefficient: −0.3312; standard error: 0.0327; R−squared: 0.7679.

Arable Land Reallocation to Permanent Pasture

- County data from the agricultural census from the 1870s onwards



Note: Slope coefficient: 0.3208; standard error: 0.0922; R−squared: 0.1620.

Event-Study Specifications

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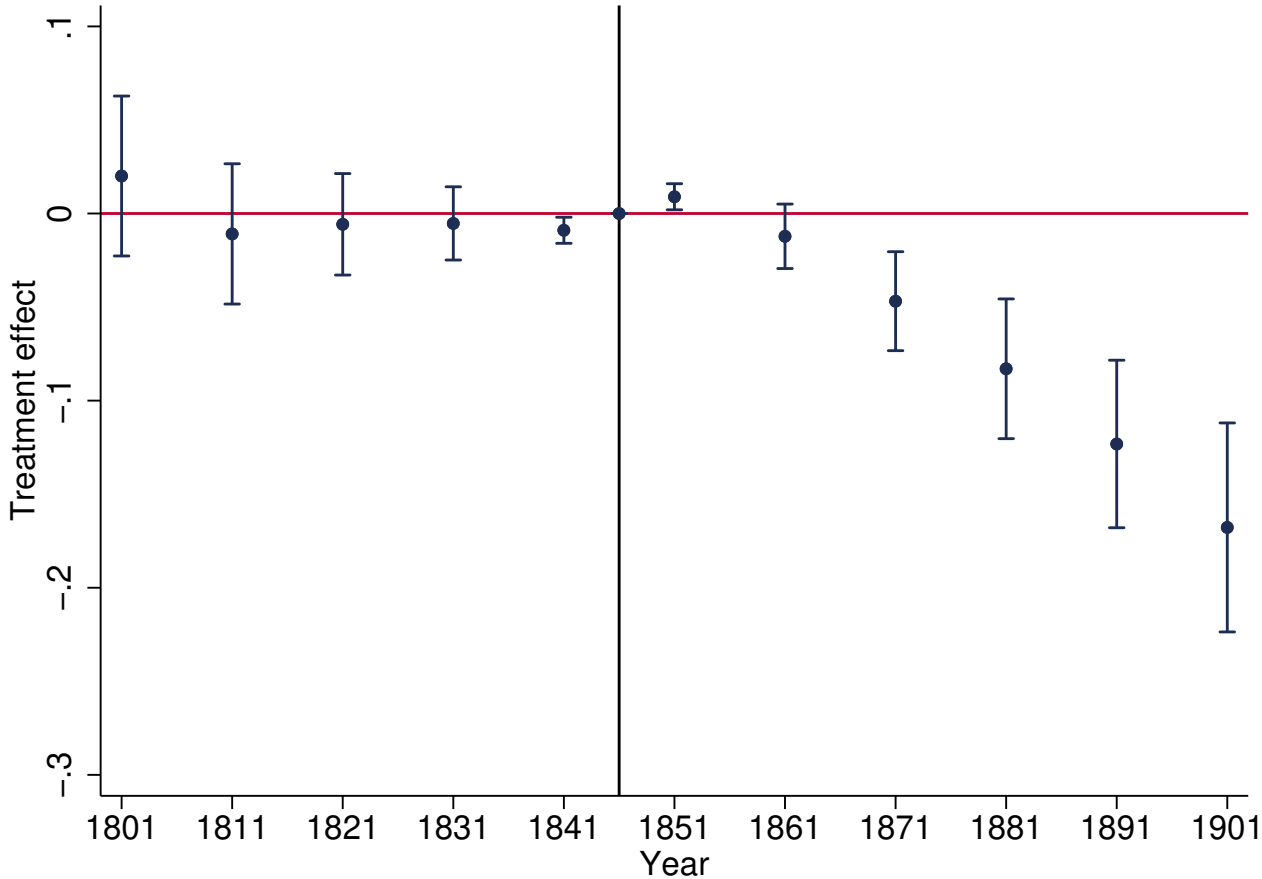
- "Difference-in-differences" regression specification

$$\ln Y_{it} = \eta_i + \sum_{\tau=-T}^{\tau=T} \beta_\tau \left(\mathbb{I}_\tau \times \text{Wheat}_i\right) + \sum_{\tau=-T}^{\tau=T} \left(X_i \times \delta_\tau\right) + d_t + u_{it}$$

- Parishes i, calendar year t and treatment year τ
- $\mathbb{I}_\tau$: Indicator for treatment year τ (1841 excluded)
- Wheat_i: Indicator for parishes with above average wheat suitability
- X_i: Controls for
  - Distance to nearest of 76 industrial centers $\times$ year
  - Distance to London $\times$ year
  - Distance to Manchester $\times$ year
  - Distance to nearest coalfield $\times$ year
  - Urban indicator (based on 1801 population density) $\times$ year
  - Wales indicator $\times$ year
- Standard errors clustered by poor law union
  - Robustness using alternative clustering
  - Robustness using alternative difference-in-differences estimators

Log Population



- Coefficients on above-median wheat suitability interacted with year
- Controls for parish characteristics interacted with year: distance to London / Manchester / other cities, distance to coal, urban, Wales

Migration
Individual-Level Data

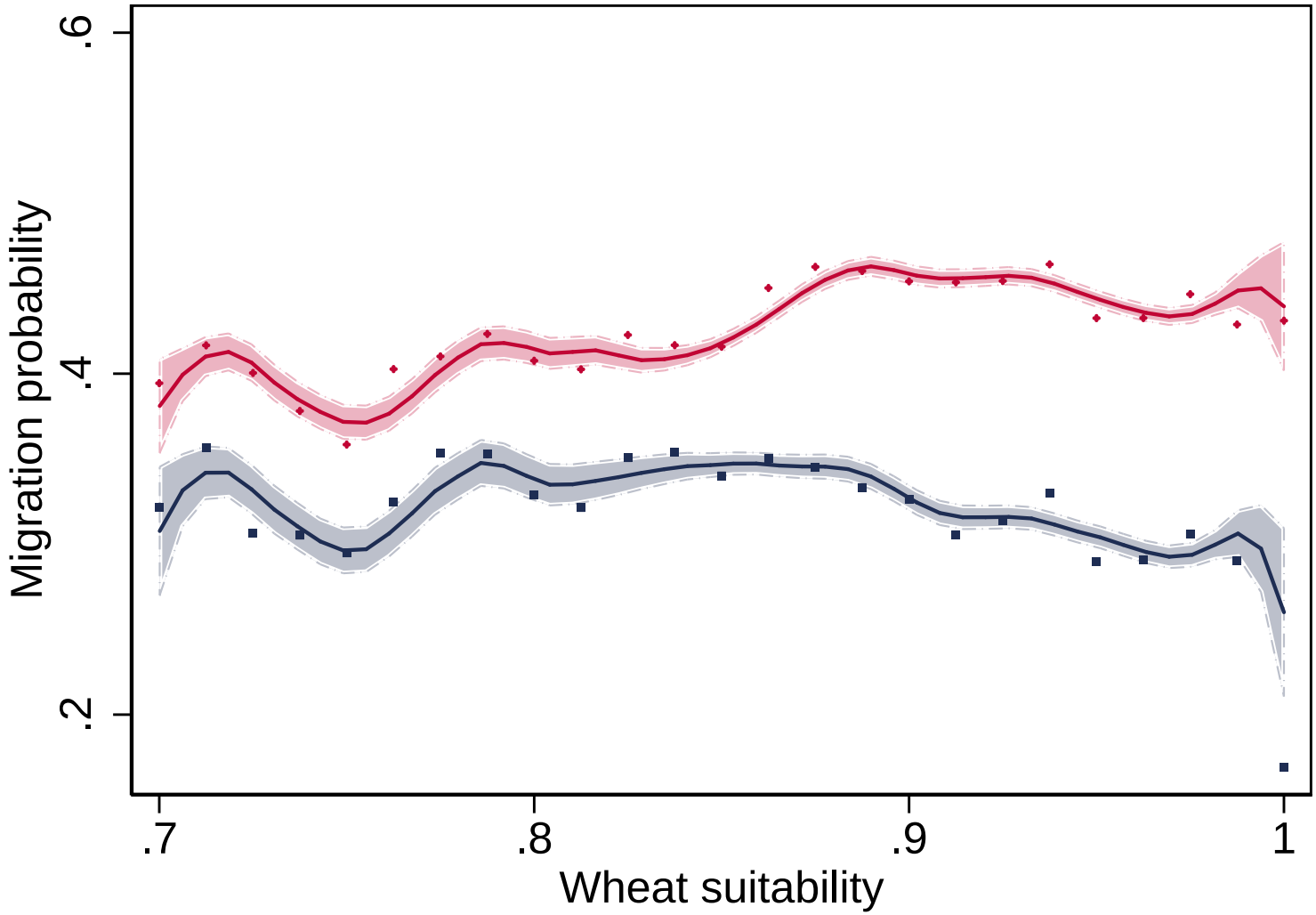
Individual-Level Data

- Follow closely the name matching algorithms used to construct linked population census data in US (Abramitzky et al. 2020)
  - Match on name, year of birth, and county of birth for men

Period	Obs Matched	Mover Parish	Mover Reg District	Mover County
		11,425	575	58
1851-1861	5,323,072	0.39	0.32	0.19
1861-1881	3,686,306	0.56	0.48	0.30
1881-1891	7,527,280	0.38	0.31	0.20
1891-1901	12,151,542	0.47	0.32	0.19
1861-1901	1,003,442	0.75	0.59	0.35

Period	Obs	Mover Birth County
1851	17,563,681	0.40
1861	19,582,103	0.42
1881	25,954,290	0.41
1891	28,902,486	0.44
1901	31,909,682	0.45

Out Migration & Wheat Suitability



- Blue (1851-1861); Red (1861-1881, 1881-1891 & 1891-1901)

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Model Outline

- World economy consists of many locations indexed by $i, j \in \mathcal{J}$
- Preferences defined over goods consumption from each sector k: Agriculture (A), Manufacturing (M), and Services (S) (incld. housing)
- Disaggregated agricultural goods g: Arable (G), Pastoral (F)
- Locations are small open economies facing exogenous prices for traded goods (Arable, Pastoral, and Manufacturing)
- Services are non-traded
- Locations can differ in amenities, average productivities by sector and good, land area, and trade costs
- Each location is endowed with a continuum of land plots $\varphi \in L_i$ that are subject to idiosyncratic productivity shocks for each land use
- Two types of agents: workers (mobile) and landlords (immobile)
- Each worker is endowed with one unit of labor
- Workers have idiosyncratic preferences for locations and choose their preferred location given their idiosyncratic preference draws

Preferences

- Worker ψ who choose to live in location i obtains the following utility

$$u_i(\psi) = B_i b_i(\psi) \left[\sum_{k \in \{A,M,S\}} (\beta_k C_{ki})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \qquad 0 < \sigma < 1$$

- with amenities B_i, idiosyncratic preferences $b_i(\psi)$, sector consumption C_{ki}
- Idiosyncratic amenities drawn from Fréchet distribution:

$$F(b) = e^{-b^{-\chi}}, \qquad \chi > 1$$

- Agricultural consumption defined over arable and pastoral products

$$C_{Ai} = C_{Gi}^{\beta_G} C_{Fi}^{1-\beta_G}, \qquad 0 < \beta_G < 1$$

- Arable, Pastoral and Manufacturing traded subject to iceberg costs
- Services non-traded

Production

- Cobb-Douglas production technologies for sectors $k \in \{A, M, S\}$ and disaggregated agricultural goods $g \in \{G, F\}$

$$q_{ki}(\varphi) = \vartheta_k n_{ki}(\varphi)^{1-\alpha_k} z_{ki}(\varphi)^{\alpha_k}, \qquad 0 < \alpha_k < 1$$
$$q_{gi}(\varphi) = \vartheta_g n_{gi}(\varphi)^{1-\alpha_g} z_{Ai}(\varphi)^{\alpha_g} a_{gi}(\varphi)^{\alpha_g}, \qquad 0 < \alpha_g < 1$$

- $\{n_{ki}, n_{gi}\}$ employment densities per unit of land; $\{z_{ki}\}$ sectoral productivity; $\{a_{gi}\}$ agricultural goods productivity
- Sectoral and goods productivities draw from Fréchet distributions

$$F_{Ki}(z) = e^{-T_{Ki} z^{-\theta}}, \qquad \theta > 1,$$

$$F_{gi}(a) = e^{-E_{gi} a^{-\epsilon}}, \qquad \epsilon > 1$$

- First, observe realizations for sectoral productivity (z), and allocate each land plot to each sector
- Second, after allocating a land plot to agriculture, observe realizations for goods productivity (a) and allocate that land plot to each good

Land and Population Shares

- Agricultural land shares

$$\ell_{gi}^{A} \equiv \frac{L_{gi}}{L_{Ai}} = \frac{E_{gi}\left(P_{gi}/w_i\right)^{\epsilon/\alpha_g}}{\sum_{h\in\{G,F\}} E_{hi}\left(P_{hi}/w_i\right)^{\epsilon/\alpha_h}}, \qquad g \in \{G, F\}$$

- Land shares

$$\ell_{ki} \equiv \frac{L_{ki}}{L_i} = \frac{T_{ki}\mathcal{P}_{ki}^{\theta}}{\sum_{s\in\{A,M,S\}} T_{si}\mathcal{P}_{si}^{\theta}}, \qquad k \in \{A, M, S\}$$

$$\mathcal{P}_{ki} \equiv \left(\frac{P_{ki}}{w_i}\right)^{\frac{1}{\alpha_k}}, \quad k \in \{M, S\}, \quad \mathcal{P}_{Ai} \equiv \gamma_\epsilon \left[\sum_{g\in\{G,F\}} E_{gi}\left(\frac{P_{gi}}{w_i}\right)^{\frac{\epsilon}{\alpha_g}}\right]^{\frac{1}{\epsilon}}$$

- Population shares

$$\lambda_i = \frac{\left(B_i w_i / P_{Ci}\right)^{\chi}}{\sum_{m\in\mathcal{J}} \left(B_m w_m / P_{Cm}\right)^{\chi}}$$

Model Mechanisms

- Grain Invasion modelled as a fall in the world price of arable products (P_G^*), holding constant (P_F^*, P_M^*)
  1. $P_G^* \downarrow$ directly reduces arable agricultural land share $\ell_{Gi}^A \downarrow$
  2. $P_G^* \downarrow$ directly reduces $\mathcal{P}_{Ai} \downarrow$ and agricultural land share $\ell_{Ai} \downarrow$
  3. Reallocations of land away from agriculture, and away from arable farming within agriculture, reduce agricultural employment: $N_{Ai} \downarrow$
  4. Locations with larger initial ℓ_{Gi}^A and ℓ_{Ai} experience larger declines in agricultural employment ($N_{Ai} \downarrow$), larger declines in wages ($w_i \downarrow$), and a population reallocation to other locations ($N_i \downarrow$)

- Grain Invasion leads to: (i) Structural transformation away from agriculture; (ii) Reallocation within agriculture from arable to pastoral farming; (iii) Rural depopulation that is concentrated in areas with high initial arable land shares; (iv) Changes in income distribution across locations with different initial arable land shares

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Parameterization

- Elasticity of substitution across sectors (e.g., Rogerson 2008)

$$\sigma = 0.5$$

- Calibrate the expenditure shares on arable and pastoral products using expenditure survey data from Allen and Bowley (1935)

$$\beta_G = 0.5, \qquad \beta_F = 0.5$$

- Calibrate production cost shares using data from Feldstein (1972), Deane and Cole (1967), and Census (1851)
  - Share of land in agricultural costs (0.31) and arable farming 1.5 times as intensive as pastoral farming

$$\alpha_F = 0.34, \ \alpha_G = 0.25$$

    Share of land in agricultural costs (0.31), Share of land in national income (0.15), and share of agriculture in national income of 0.23

$$\alpha_M = \alpha_S = \alpha_N = 0.10$$

- Fréchet shape parameters within agriculture (ϵ) and across sectors (θ)

$$\epsilon = 3, \qquad \theta = 2$$

- Migration elasticity (Bryan and Morten 2019, Galle et al. 2020)

Quantitative Analysis

- Observe employment (N_{it}, N_{Ait}), rateable values ($\mathbb{V}_{it} = r_{it}L_i$), agricultural land shares (ℓ^A_{Git}, ℓ^A_{Fit}), and land area (L_i)
- Agric cost share (α_{Ait}) from cost minimization and zero profits

$$\alpha_{Ait} = \alpha_G \left(\frac{\frac{1}{\alpha_G}\ell^A_{Git}}{\frac{1}{\alpha_G}\ell^A_{Git} + \frac{1}{\alpha_F}\ell^A_{Fit}} \right) + \alpha_F \left(\frac{\frac{1}{\alpha_F}\ell^A_{Fit}}{\frac{1}{\alpha_G}\ell^A_{Git} + \frac{1}{\alpha_F}\ell^A_{Fit}} \right)$$

- Wages (w_{nt}) from cost minimization and land market clearing

$$w_{it} = \frac{\mathbb{V}_{it}}{\frac{\alpha_{Ait}}{1-\alpha_{Ait}} N_{Ait} + \frac{\alpha_N}{1-\alpha_N} \left[N_{it} - N_{Ait} \right]}$$

- Sectoral land shares (ℓ_{kit}) from cost minimization

$$\begin{aligned} \ell_{Ait} &\equiv \frac{L_{Ait}}{L_i} &&= \frac{\alpha_{Ait}}{1-\alpha_{Ait}} \frac{w_{it}}{r_{it}} \frac{N_{Ait}}{L_i} \\ \ell_{kit} &\equiv \frac{L_{kit}}{L_i} &&= \frac{\alpha_N}{1-\alpha_N} \frac{w_{it}}{r_{it}} \frac{N_{kit}}{L_i}, \qquad k \in \{M, S\} \end{aligned}$$

- Recover implied unobserved amenities and sectoral productivities

Counterfactuals

- Denote counterfactual by prime (e.g., x_j'), observed value no prime (e.g., x_j), and relative change by a hat (e.g., $\widehat{x}_j \equiv x_j' / x_j$)
- Counterfactual fall world arable price ($\widehat{P}_G^* < 1$), holding constant world pastoral ($\widehat{P}_F^* = 1$) and manufacturing ($\widehat{P}_M^* = 1$) prices

Proposition

(Exact-Hat Algebra) *Given the demand parameters (σ, β_G, β_F), production cost parameters (α_k), productivity and preference dispersion parameters (ϵ, θ, χ), and data by location i and year t on employment by sector (N_{Ait}, N_{Mit}, N_{Sit}), agricultural land shares for arable and pastoral farming (ℓ^A_{Git}, ℓ^A_{Fit}), total land area (L_i), and rateable values ($\mathbb{V}_{it} = r_{it} L_i$), and counterfactual changes in world relative prices for traded goods ($\widehat{P}^*_{Gt}$, $\widehat{P}^*_{Ft}$, $\widehat{P}^*_{Mt}$), the solution for counterfactual changes in the model's endogenous variables does not require information on the level of the location characteristics (E_{git}, T_{kit}, τ_{kit}, B_{it}).*

Distributional Consequences

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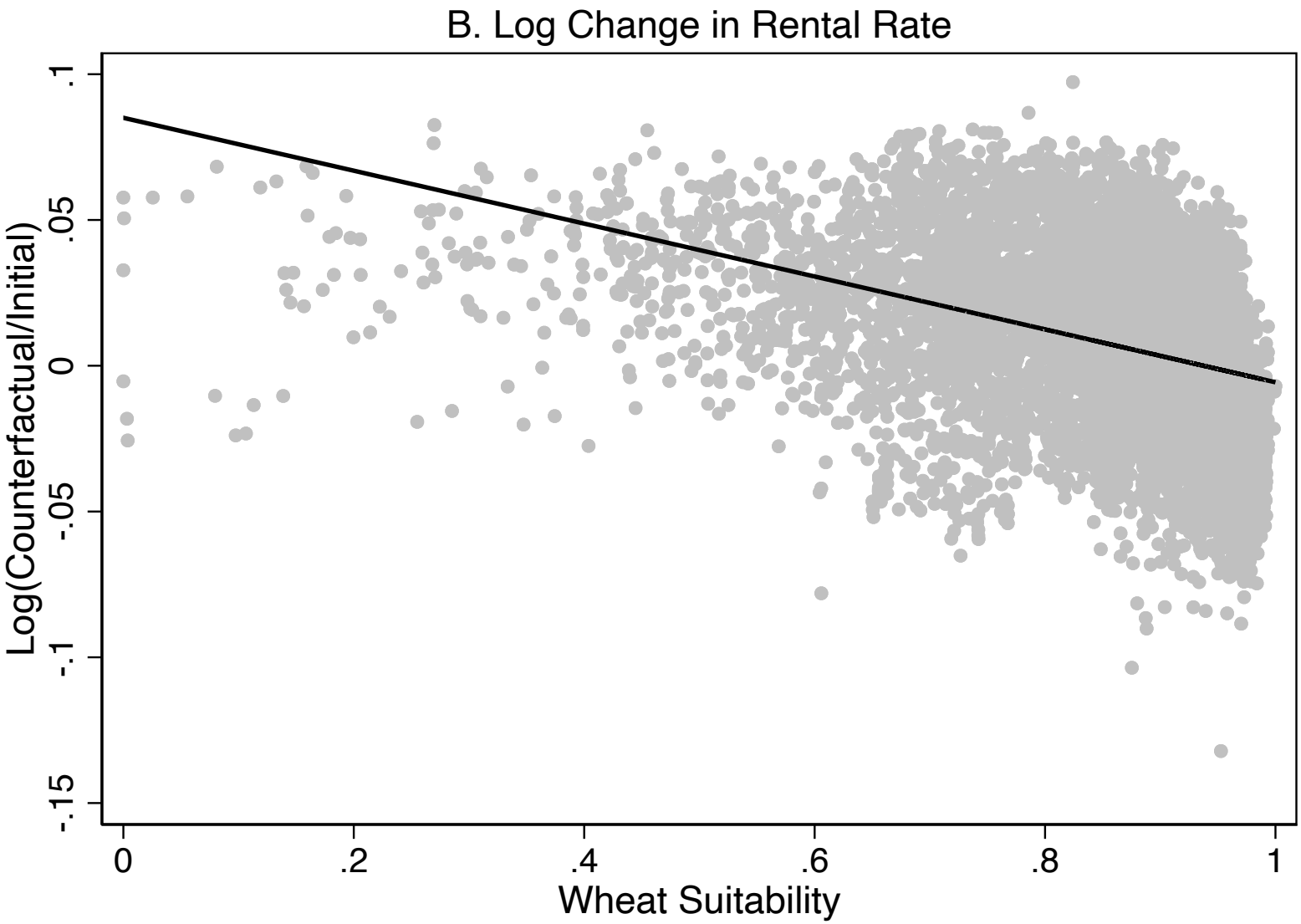
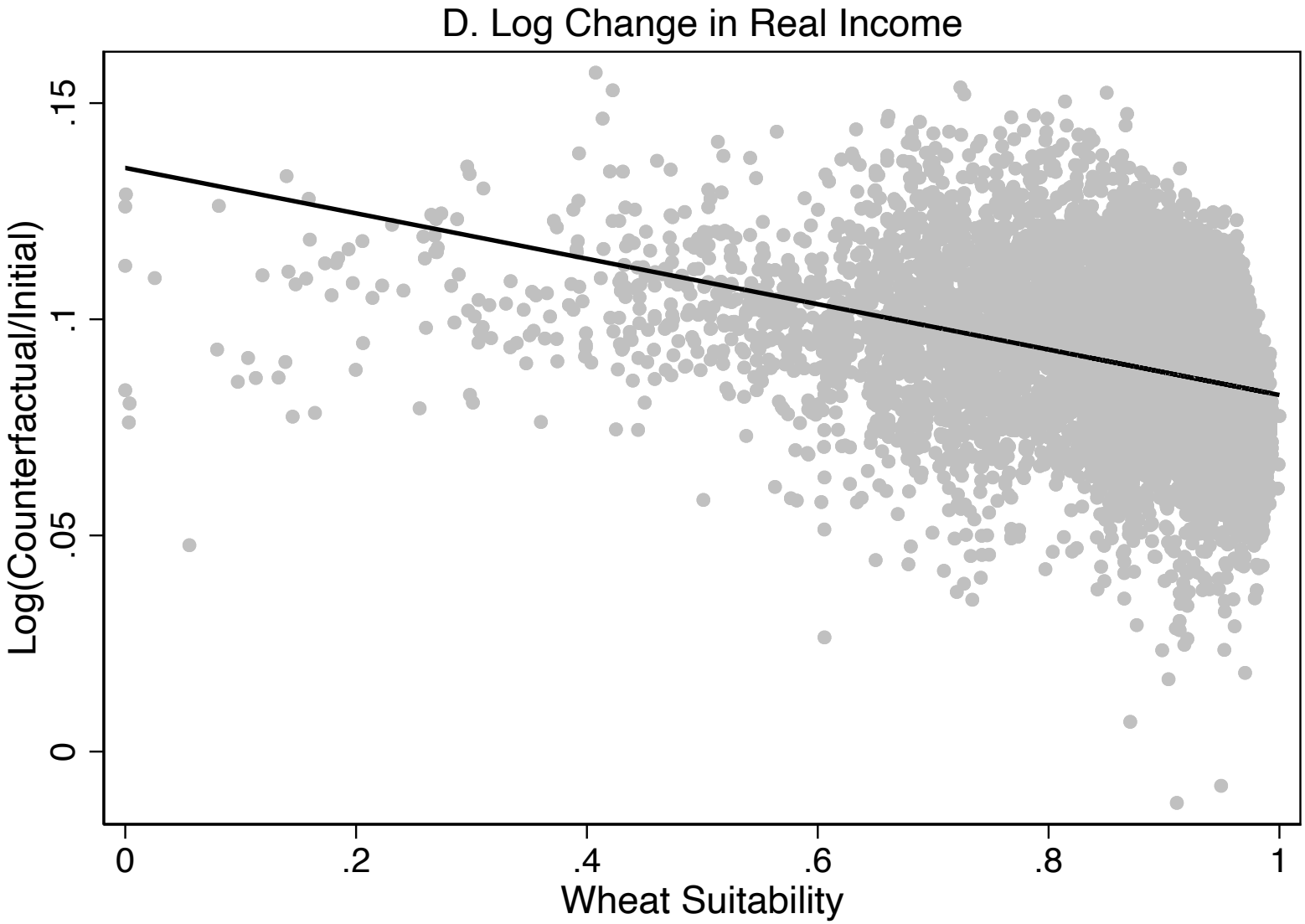
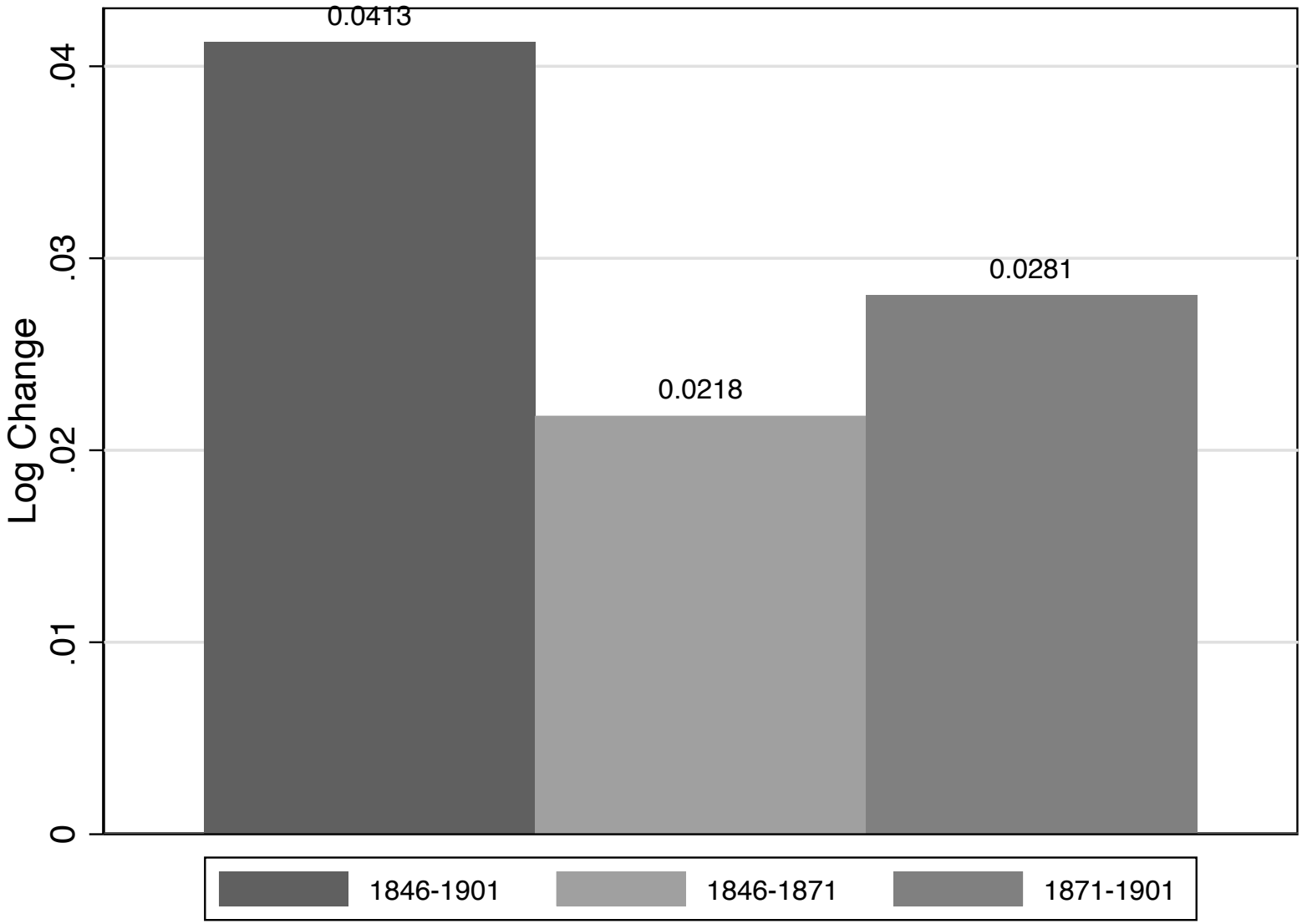


Distributional Consequences



Worker Expected Utility



Conclusions

- The income distributional consequences of trade is one of the central questions in international economics
- We examine one of the most influential historical trade shocks: Grain Invasion following the Repeal of the Corn Laws in 1846
- Traditionally, research on the Grain Invasion has emphasized economy-wide distributional effects across factors or industries
  - Heckscher-Ohlin and Specific-Factors models
  - Urban workers / manufacturers versus rural aristocracy
- We provide new evidence on the distributional consequences across different geographical areas within England and Wales
  - New, spatially-disaggregated data on population, employment, property values and pauperism from 1801-1901
  - Exogenous exposure measure based on agroclimatic conditions
  - Substantial reduced-form estimated treatment effects
  - Quantitative spatial model implies modest gains in worker expected utility and large distributional consequences across locations

Thank You