Railroads of the Raj

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Contributions

- Building railroads raised real income in India by 20%.
- Introduces a powerful method to calculate transport costs.
- Reformulates Ricardian trade model for agriculture.
- New standard for connecting vast amounts of historical data to a structural model.
- Template for modelling global effects of climate change?

Transport Costs and How They Fell

- Pricing equation for a good shipped from origin o to destination d:

$$P_{dt}^{o} = P_{ot}^{o} T_{odt}^{o}.$$

- Iceberg specification works for Armington, Monopolistic competition, or Ricardian model.

- Salt was "branded" according to 8 distinct origins o in India.

- Collects annual data from 1861-1930 on price P_{dt}^{o} of o salt in each of 124 districts (o is not one of districts).

- Data on transport network $\mathbf{R}_t$ from 8 origins to 128 destinations, rail, road, river, and coast.

- Assume constant coefficients for cost per unit distance relative to rail: $\alpha^{rail} = 1$, α^{road}, α^{river}, and α^{coast}.

- Use Dijkstra's algorithm to calculate $LCR(\mathbf{R}_t, \alpha)_{odt}$: rail distance from o to d at date t that mimics actual best combination of transport.

- Estimates: $\alpha^{rail} = 1$, $\alpha^{road} = 7.3$, $\alpha^{river} = 3.4$, $\alpha^{coast} = 3.2$, and an elasticity $\delta = 0.25$ of iceberg cost with respect to LCR.

- I'd like to interpret δ as rail cost per mile per Dollar shipped:

$$\ln P_{dt}^{o} = \beta_{ot}^{o} + \ln\left[1 + \delta * LCR(\mathbf{R}_t, \alpha)_{odt}\right].$$

Incredible Detail of Data

- For 239 districts in India, 1861-1930 (first track laid in India, 1853).
- Daily rainfall data by district (India's economy dominated by non-irrigated agriculture).
- Bilateral trade between 45 trade blocks and 23 foreign countries for each of 85 commodities.
- Yields and land under cultivation by district for each of 17 principle crops: barley, chick pea, corn, cotton, indigo, sorghum, opium, rice, sesame, sugar, lentils, wheat, ...

Model I

- Utility of the representative agent in district d

$$\ln U_d = \sum_{k=1}^{K} \mu_k \left[\frac{\sigma_k}{\sigma_k - 1}\right] \ln \int_0^1 \left[C_d^k(j)\right]^{(\sigma_k - 1)/\sigma_k} dj.$$

- Ricardian land yield for variety $j \in [0, 1]$ of good k:

$$\Pr[Z_d^k(j) \leq z] = e^{-A_d^k z^{-\theta_k}}$$

- Price index, assuming $\sigma_k < \theta_k + 1$:

$$P_d^k = \lambda_1^k \left[\sum_{o=1}^{D} A_o^k (r_o T_{od}^k)^{-\theta_k}\right]^{-1/\theta_k}.$$

- Trade share

$$\pi_{od}^{k} = \frac{X_{od}^{k}}{X_{d}^{k}} = \lambda_{3}^{k} A_{o}^{k} \left(\frac{r_{o} T_{od}^{k}}{P_{d}^{k}} \right)^{-\theta_{k}} .$$

Key Relationships

- Bilateral trade equation to estimate θ_k and relate A_o^k to rainfall:

$$\ln X_{od}^k = \ln \lambda_3^k + \ln A_o^k - \theta_k \ln T_{od}^k + \theta_k \ln P_d^k + \ln X_d^k.$$

- Back out land rent with good k as numeraire:

$$\frac{r_o}{P_o^k} = \left(\frac{\pi_{oo}^k}{\lambda_3^k A_o^k} \right)^{-1/\theta_k}.$$

- Gives real income per unit of land:

$$W_o = \frac{r_o}{\widetilde{P}_o} = \prod_{k=1}^{K} \left(\frac{r_o}{P_o^k} \right)^{\mu_k}.$$

- Hence:

$$\ln W_o = \Omega + \sum_{k=1}^{K} \frac{\mu_k}{\theta_k} \ln A_o^k - \sum_{k=1}^{K} \frac{\mu_k}{\theta_k} \ln \pi_{oo}^k$$

- Gains from: intra-good trade, inter-good trade, inter-temporal trade.

Interpretation

- Its a structural model, so we can think through what it means.
- Random yields at the level of varieties j smooths out the Ricardian model in a useful way.
- Best interpretation: seed varieties (not variation in land quality or the weather).
- But do consumers really care what variety of chick pea they're eating?

- I'd expect $\sigma_k = 20$, but then θ_k must also be large for a well defined price index for chick peas.

- Problem: the estimate of θ_k are more like 3 to 5 (could use more detail in the paper).

Solution I

- Go for the case with very high σ_k and θ_k.
- Almost all the gains from trade come from inter-good trade, as in a traditional Ricardian model.
- The continuum of varieties is more of a device to make the model behave nicely.
- Figure out why estimates of θ_k are downward biased.

Solution II

- Aggregate! Why run bilateral trade equations with 85 commodities?.
- The point of varieties is to not fuss with all the detail: (i) grains, (ii) other.
- Aggregation will eliminate a huge amount of measurement error.
- Now we'd expect to see much lower estimates of θ_k, perhaps similar to the current ones.
- Much of the gains from trade will come from intra-good trade.