Robots, Trade, and Luddism
by Arnaud Costinot & Iván Werning

Brian C. Albrecht, V. V. Chari,
Adway De, & Keyvan Eslami

University of Minnesota
&
Federal Reserve Bank of Minneapolis

Becker-Friedman Institute
Conference on Taxation & Fiscal Policy
May, 2018
Costinot-Werning Contribution

- Claims by many non-economists:
  - Increased trade with China made some people worse off
    - *Only* remedy is to reduce trade
  - Robots will lead to widespread misery
    - *Only* remedy is to ban robots

- C-W show: If government cares about redistribution, even if tax instruments are somewhat restricted, these claims are wrong
Are C-W instruments restricted? Not really

Argue that C-W results are very nice and helpful
Mechanism Design Question

- Can we write down hidden trade environment in which “prices” show up in incentive constraints?

- If so, tax system is not “restricted”
- 2 consumption goods: “happy meals” and “tractors”
- 2 types of labor: skilled and unskilled
- Equal measures of 2 types of household: skilled, $\theta_s$, and unskilled, $\theta_u$
- Utility:
  \[ U(\theta) = U_\theta (c(\theta), l(\theta)) \]
- Resource constraint:
  \[ C^i = F^i (L^i(\theta_s), L^i(\theta_u)) \]
Competitive Equilibrium with Nonlinear Taxes

- Allocation: \( c(\theta) = (c^1(\theta), c^2(\theta)) \), \( l(\theta) = (l^1(\theta), l^2(\theta)) \)

- Consumer prices: \( \tilde{p} = (\tilde{p}^1, \tilde{p}^2) \), \( w = (w(\theta_s), w(\theta_u)) \)

- Producer prices: \( p = (p^1, p^2) \), \( w = (w_s, w_u) \)

- Tax function \( T(wl) \) can depend only on labor income \( wl \)

- Pre-tax labor income: \( R(\theta) = w(\theta) [l^1(\theta) + l^2(\theta)] \)

- Standard definition of competitive equilibrium

- Problem: Find the best competitive equilibrium
Choose allocations and prices to solve

$$\max \sum \lambda(\theta) U(\theta)$$

subject to

- Incentive compatibility:

$$U^\theta \left( c(\theta), \frac{R(\theta)}{w(\theta)} \right) \geq U^\theta \left( c(\hat{\theta}), \frac{R(\hat{\theta}) w(\hat{\theta})}{w(\theta)} \right)$$

- Firms’ first order conditions

- Resource feasibility
Recall production efficiency for convex technologies simply says allocation is on frontier of production possibility set:

\[
\frac{F^1_{\theta_s}}{F^1_{\theta_u}} = \frac{F^2_{\theta_s}}{F^2_{\theta_u}}
\]

Note that in this Ramsey problem, prices show up in incentive constraints:

- So, Ramsey allocations typically not production efficient.
Our Mechanism Design Challenge

- Write down a physical environment in some detail that produce same problem as Ramsey problem
- Don’t restrict outcomes to “competitive equilibria”
Hidden Trade Environment

- Happy meals and tractors produced in area populated by many factories
- Each factory produces one type of good
- Planner at the gate to area asks if people going in are skilled or unskilled
- Private agents announce type and go in to produce
- Planner *cannot observe trade* inside factory
- After production, leave area with happy meals and tractors
- People cannot consume until after they leave
- Planner can observe vector of happy meals and tractors when agents leave gate
Allocation:

- Consumption: \( c(\theta) = (c^1(\theta), c^2(\theta)) \)
- Required output delivery at gate: \( y(\theta) = (y^1(\theta), y^2(\theta)) \)
- Recommended labor input: \( l(\theta) = (l^1(\theta), l^2(\theta)) \)

Hidden trade: Within each factory agent chooses how much to produce and how to split up output.
Agents within each factory choose how much surplus to produce and how to divide it up.

Take as given how other factories are making their choices.

Take as given required output delivery, \( y^i (\theta) \), and consumption, \( c^i (\theta) \).

Call this the *factories game*.
Lemma: There is an equilibrium of the factories game in which

\[ y^i(\theta) = F^i_{\theta}(\ell(\theta_s), \ell(\theta_u)) \ell(\theta) \]

Proof:

- At each factory, agents first maximize surplus, then decide how to split it.
- For surplus maximization, choose measure and labor input of each type, \( n(\theta) \) and \( \hat{l}(\theta) \), to solve

\[
\max \quad F^i \left( n(\theta_s) \hat{l}(\theta_s), n(\theta_u) \hat{l}(\theta_u) \right) - \sum_{\theta} y^i(\theta) n(\theta) \\
\text{s.t.} \quad \hat{l}(\theta) \leq l(\theta)
\]

- Clearly the solution satisfies the above condition
Miri11e1s Problem with Hidden Trade

- Mirrlees problem is now to choose \( c^i (\theta) \), \( y^i (\theta) \), and \( l^i (\theta) \) to solve

\[
\text{maximize} \quad \sum \lambda (\theta) U(\theta) \\
\text{subject to} \quad U^\theta \left( c(\theta), \frac{y^1(\theta)}{F^1_\theta} + \frac{y^2(\theta)}{F^2_\theta} \right) \\
\geq U^\theta \left( c(\hat{\theta}), \frac{y^1(\hat{\theta})}{F^1_\theta} + \frac{y^2(\hat{\theta})}{F^2_\theta} \right)
\]

\[ y^i (\theta) = F^i_\theta (l(\theta_s), l(\theta_u)) l(\theta) \]

Resource Constraint
Results for Mirrlees Problem

- **Theorem:** Mirrlees allocations typically not production efficient

  \[
  \frac{F_{\theta_s}^1}{F_{\theta_u}^1} \neq \frac{F_{\theta_s}^2}{F_{\theta_u}^2}
  \]

- **Exception:** \( F^i = \theta_s l^i (\theta_s) + \theta_u l^i (\theta_u) \)

- **Proposition:** If preferences weakly separable in consumption and labor, *uniform commodity taxation* holds:

  \[
  \frac{U_1 (\theta_s)}{U_2 (\theta_s)} = \frac{U_1 (\theta_u)}{U_2 (\theta_u)} \left( \neq \frac{F_{\theta}^2}{F_{\theta}^1} \right)
  \]
Why We Like Our Physical Environment

- With a single good, this is how we think of Mirrlees

- In Mirrlees, planner observes \( c(\theta) \) and \( y(\theta) \), and recommends \( l(\theta) \)

- \( y(\theta) = \theta l(\theta) \)

- Incentive compatibility:

\[
u^\theta \left( c(\theta), \frac{y(\theta)}{\theta} \right) \geq u^\theta \left( c(\hat{\theta}), \frac{y(\hat{\theta})}{\theta} \right)\]
Vector of outputs and labor inputs:

\[
\{ y^i \}_{i=1}^N \quad \text{and} \quad \{ n(\theta) \}_{\theta \in [\theta, \bar{\theta}]}
\]

Old technology:

\[
G \left( \{ y^i \}, \{ n(\theta) \} \right) \leq 0
\]

New technology:

\[
G^* \left( \{ y^*i \}, \phi \right) \leq 0
\]
Costinot-Werning Problem, Rewritten

- Ramsey problem is to choose

\[ c(\theta), n(\theta), y^i, y^{i*}, p^i, p^{i*}, q^i, \text{ and } w(\theta) \]

to solve

\[ W := \max \int U(\theta) \, d\Omega(\theta) \]

s.t. \[ U(\theta) = \max_{\theta'} U\left( c(\theta'), n(\theta') \frac{w(\theta')}{w(\theta)} \right) \]

\[ G^* (\{ y^{i*} \}, \phi) \leq 0 \]

- Since \( G^* \) does not have \( n \), never want to distort it

- Minor comment 1: All the information on \( G \) buried in \( \mathcal{P} \). Put it in explicitly?

- Minor comment 2: Set up as a Pareto problem rather than fixed \( \Omega \) weights
Costinot-Werning Main Result (In My View)

- Envelope theorem:

\[
\frac{dW}{d\phi} = \gamma \frac{dG^*}{d\phi}
\]

- Technologies change raises welfare iff production possibility of new firms expand
Summary

- Very cool paper
- **Lots** of interesting results
- Maybe “restricted” tax system is not important after all