Innovation and Trade Policy
in a Globalized World

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Motivation - United States in the Late 1970s

Labor Productivity Growth in Manufacturing
(output/hour, in %, 1976−80 avg.)

Growth in Patenting
(Patent Applications in the U.S., in %, 1976-80 avg.)

Akcigit, Ates, Impullitti (2017)
Foreign competition in the technology intensive industries poses a more serious threat to our country's position in the international marketplace than ever before in our history.

John P. McTague (1985)\(^a\)

\(^a\)Associate Director of the Office of Science and Technology Policy of the Reagan Administration.
Motivation - United States in the Late 1970s

“... these industries are dominated by a few nations and firms so that competitive advantage brings significant economic profits and political influence. Thus, if the United States becomes a net importer and a technically inferior producer, it would also become a less independent, less influential and less secure nation.”

U.S. Council of National Security (1986)
Make America Great Again!

Introduction of federal R&D tax credit (ERTA)

US Share in Total Patents (dashed)

R&D/Sales (solid)

R&D Intensity - - - Patenting Share of the U.S.

Akcigit, Ates, Impullitti (2017)
State-level R&D tax credit policies were also enacted.

Akcigit, Ates, Impullitti (2017)
R&D Policies in Other Countries

Introduction of R&D tax credit (ERTA)

Changing the base calculation

Federal/National R&D Subsidy Rate

Year

1980 1985 1990 1995

US UK JAP ITA FRA GER

Akcigit, Ates, Impullitti (2017)
Motivating Questions

▷ What are the welfare effects of industrial policies in an open economy with foreign technological competition?

▷ Managing international competition:
  ▷ **Protectionism** as a response to foreign technological catching up
  ▷ **R&D subsidies** as an alternative response to foreign catching up

▷ How do the answers depend on the policymaker’s horizon?
To Answer These Questions...

- **Model:**
  - Open economy DGE model with endogenous technological progress
  - Two large economies subject to trade frictions
  - Step-by-step innovation with strategic interaction
  - Endogenous entry-exit
  - Transitional dynamics: important for policy horizon

- **Quantitative analysis**
Main Mechanism in the Model

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

Innovation effort

Technological gap btw. domestic and foreign firms

Import

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

Technological gap btw. domestic and foreign firms

Innovation effort

Technological gap btw. domestic and foreign firms

Import

No Trade

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

- Defensive R&D
- Expansionary R&D

Technological gap btw. domestic and foreign firms

Import

No Trade

Export

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

Akçigit, Ates, Impullitti (2017)
Main Mechanism in the Model

**Retaliation:**

Akcigit, Ates, Impullitti (2017)
Main Mechanism in the Model

R&D Subsidy:

![Graph showing the relationship between innovation effort and technological gap between domestic and foreign firms.]

Innovation effort vs. Technological gap btw. domestic and foreign firms.
Preview of the Results

1. **Static effects:**
   - Protectionism could benefit firms (and the overall welfare) by keeping the profits in the country.

2. **Dynamic effects:**
   - Catching up: more innovation through escape competition and through technology transfer
   - Protectionism: less innovation less technology sourcing

3. Protectionism yields welfare gains in the short run (10 yrs.) but large long-run losses

4. R&D subsidies is the dominant policy for long-sighted policy makers

5. **Policy complementarity:** lower trade barriers imply lower optimal subsidy
MODEL

Part 1. Static Environment
Preferences

- There is a representative household in each country:

\[ U_c(t) = \int_t^\infty \exp(-\rho(s-t)) \frac{C_c^{1-\varepsilon}(s) - 1}{1 - \varepsilon} ds. \]  
(3)

- Household owns: fixed factor \((L_c = 1)\) and assets of domestic firms \((A_c)\)

- Budget constraint

\[ r_c(t)A_c(t) + L_c\omega_c(t) = C_c(t) + \dot{A}_c(t) + T_c(t), \]  
(4)

- Asset markets

\[ A_c(t) = \int_0^1 (V_{cj}(t) + \tilde{V}_{cj}(t))dj. \]
Preferences

- There is a representative household in each country:
  \[ U_c(t) = \int_t^\infty \exp(-\rho(s-t)) \frac{C_c^{1-\varepsilon}(s) - 1}{1 - \varepsilon} ds. \]  
  (1)

- Household owns: fixed factor \((L_c = 1)\) and assets of domestic firms \((A_c)\)

- Budget constraint
  \[ r_c A_c + L_c \omega_c = C_c + \dot{A}_c + T_c, \]  
  (2)

- Asset markets
  \[ A_c = \int_0^1 (V_{cj} + \tilde{V}_{cj}) dj. \]
Final Good

- Final good in country $c$ produced with technology

$$Y_c = \frac{L_c^\beta}{1 - \beta} \int_0^1 q_{c'j}^{\beta} k_{c'j}^{1 - \beta} dj,$$

where $c' \in A, B$ (5)

- $L_c$: Labor, fixed factor, immobile, normalized to 1.
- $j \in [0, 1]$: intermediate variety.
- $q_{cj}$: quality of variety $j$ in country $c$
- $k_{cj}$: amount of variety $j$ used.
- Highest quality good (adjusted for trade cost) is purchased.
Intermediate Goods

- In each $j$, one firm per country competing for leadership à la Bertrand.

\[
\text{Tech. Leadership in } j = \begin{cases} 
A \text{ is leader,} & \text{if } q_{Aj} > q_{Bj} \\
B \text{ is leader,} & \text{if } q_{Aj} < q_{Bj} \\
\text{Neck&Neck,} & \text{if } q_{Aj} = q_{Bj}
\end{cases}
\]

- Qualities evolve through innovation and spillovers (to be explained later).

- Intermediate goods are produced at the marginal cost of $\eta$ in terms of final good.

- Selling abroad has export cost $\kappa$. 
Final Good producer’s maximization gives

\[ p_j = q_j^\beta k_j^{-\beta}. \]

Intermediate good producer’s maximization problem when selling to domestic market

\[ \Pi (q_j) = \max_{k_j \geq 0} \left\{ q_j^\beta k_j^{1-\beta} - \eta k_j \right\}. \]
Final Good producer’s maximization gives

\[ p_j = q_j^\beta k_j^{-\beta}. \]

Intermediate good producer’s maximization problem when exporting

\[ \hat{\Pi}(q_j) = \max_{k_j \geq 0} \left\{ q_j^\beta k_j^{1-\beta} - (1 + \kappa)\eta k_j \right\}. \]
Intermediate Good Decisions II

- Equilibrium domestic profit is:
  \[ \Pi(q_j) = \pi q_j, \]

  where \( \pi \equiv \left( \frac{1-\beta}{\eta} \right)^{1-\beta} \beta. \)

- Equilibrium profit from selling abroad is:
  \[ \hat{\Pi}(q_j) = \hat{\pi} q_j, \]

  where \( \hat{\pi} \equiv \left( \frac{1-\beta}{(1+\kappa)\eta} \right)^{1-\beta} \beta. \)
Export vs Import Decisions

- Country A exports in sector $j$ iff

$$\frac{q_{Aj}}{q_{Bj}} > 1 + \kappa$$

- Country A imports in sector $j$ iff

$$\frac{q_{Bj}}{q_{Aj}} > 1 + \kappa$$
Proposition 1. Consider the static environment described above. The static change in income in the open economy relative to autarky is determined by the following forces:

1. an increase in profits from generating additional profits from exports due to higher market size;
2. a decline in profits from destruction of profits of laggard firms;
3. an increase in wages from higher labor productivity through transfer of technology.

The combined impact of these forces is ambiguous.
Decision to Trade

Akcigit, Ates, Impullitti (2017)
Decision to Trade

Akcigit, Ates, Impullitti (2017)
Decision to Trade

The graph illustrates the decision to trade profits ($\pi q$) for product line $j$ for US firms, when sold at home and abroad. The lines $H1$ and $H2$ represent different hypotheses for US firms, when sold at home, while $H1'$ and $H2'$ represent different hypotheses for US firms, when sold abroad. The graph is adapted from Akcigit, Ates, Impullitti (2017).
Decision to Trade

Profts $\pi q$

Product line, $j$

US firms, when sold at home

US firms, when sold abroad

Akcigit, Ates, Impullitti (2017)
Decision to Trade

profits

\[ \pi q \]

product line, \( j \)

H1, H2 US firms, when sold at home

H1', H2' US firms, when sold abroad

Akcigit, Ates, Impullitti (2017)
Decision to Trade

profits \( \pi q \)

US firms, when sold at home

US firms, when sold abroad

Akcigit, Ates, Impullitti (2017)
Thus, the comparison between incomes in autarky and the open economy boils down to the comparison of
\[ \int_{0}^{\infty} q_{cj} d\theta \]
and
\[ \left( 1 + \left( 1 + \kappa - \beta - \beta \right) \int_{0}^{\infty} I q_{cj} \right) > \hat{q}_{cj} \]
determining the profit component, and to the comparison of
\[ \int_{0}^{\infty} q_{cj} d\theta \]
and
\[ \int_{0}^{\infty} I q_{cj} > \hat{q}_{cj} \]
+ \left( 1 + \kappa - \beta - \beta \right) \int_{0}^{\infty} \left[ 1 - I q_{cj} \right] \hat{q}_{cj} \]
determining wages. Figure 9 illustrates these comparisons. As in Figure 8, solid lines determine the domestic technology frontier whereas dashed lines show the iceberg cost-adjusted levels of these frontiers that emerge when engaging in trade. The left panel shows the product lines and the associated qualities that determine aggregate profit income for the home country in an open world. The right panel shows the technology frontier that determines the domestic labor productivity.

(a) Effect on profits

(b) Effect on wages

Figure 9: Static effects of openness
MODEL

Part 2. Dynamic Environment
Intermediate Goods

- Qualities evolve through **innovation** and **spillovers**.
- Successful innovation generates quality jumps btw. $t$ and $t + \Delta t$:

$$q_{cj}(t + \Delta t) = \lambda^k q_{cj}(t)$$

where $\lambda > 1$, $c \in \{A, B\}$.

- $k \in \mathbb{N}^+$ is a random variable
Quality Dynamics

- If \( n_c(t) = \int_0^t k(s)ds \) is the number of quality jumps up to time \( t \)
  \[ q_{cj}(t) = \lambda^{n_c(t)}. \]

- Technology gap between \( A \) and \( B \) in \( j \)
  \[ \frac{q_{Aj}}{q_{Bj}} = \frac{\lambda^{n_{Aj}}}{\lambda^{n_{Bj}}} = \lambda^{n_{Aj} - n_{Bj}} \equiv \lambda^{m_{Aj}} \]

- **Assumption.** Max gap is \( \bar{m} \implies m_c \in \{-\bar{m}, -\bar{m} + 1, ..., 0, ..., \bar{m} - 1, \bar{m}\} \), where \( c \in \{A, B\} \)

- \( \mathcal{F}(k) \) is a distribution such that:
  - multiple step jumps are less likely: increasing difficulty
  - Backward firms more likely to multiple jumps: advantage of backwardness [à la Gerschenkron (1951)]
Step Jump Distribution, $F(k)$

$$F(n) = c_0(1 + \phi)^{-n} = F_{-\bar{m}}(n)$$

$$A$$

Figure 7: Probability mass function for new position

The treatment of $A(m)$ in the derivation of position-specific distributions serves the same purpose. An alternative could involve an equal distribution of the truncated probability $A(m)$ across potential positions $\{m + 1, \ldots, \bar{m}\}$. This alternative would imply a relatively fatter right tail in $F_m(n)$, thus higher chances of climbing up the position ladder. However, this structure would favor the U.S., most of whose firms are technological leaders in their products, more than the foreign countries, whose firms are lagging in most product lines. Even though a laggard firm can close the gap by a few steps, a leading firm in this alternative setup could easily open up the gap. This happens because, for a leading firm, equally distributing $A(m)$ across a few better positions the firm has ahead means higher chances of quickly reaching these positions again. Given that, in the data, the initial leadership distribution is strongly in favor of the U.S., this advantage for the leading firms would result in a shift of the distribution towards larger gaps, operating against the convergence process in the data.

The resulting law of motion for the quality level of an incumbent from that operates in product line $j$ at position $m$ (−\bar{m}) can be summarized as follows:

Note that this specification approaches to the standard step-by-step model as $\phi \to \infty$. 

Akcigit, Ates, Impullitti (2017)
Innovation by incumbents and entrants

- **Incumbents:**
  \[ C \left( x_j^c; q_j \right) = q_j \alpha_c \left( x_j^c \right)^\gamma_c . \]
  
  - \( z_j^c \): R&D investment
  - \( x_j^c \): Poisson arrival rate:
Innovation by incumbents and entrants

▶ Incumbents:

\[ C \left( x_j^c; q_j \right) = q_j \alpha_c \left( x_j^c \right)^{\gamma_c} . \]

▶ \( z_j^c \): R&D investment

▶ \( x_j^c \): Poisson arrival rate:

▶ Entrants:

\[ C \left( \tilde{x}_j^c; q_j \right) = q_j \alpha_c \left( \tilde{x}_j^c \right)^{\gamma_c} . \]

▶ Directed entry

▶ Drawing from same step-size distribution of domestic incumbent

Akcigit, Ates, Impullitti (2017)
Suppose the follower in line 2 innovates.

Scenario 3: It leapfrogs.

quality, $q$
Illustration of the Innovation Dynamics

Suppose the follower in line 2 innovates.

- Scenario 1: It closes the gap, but remains follower.

\[ \text{quality, } q \]

\[ \text{product line, } j \]

Akcigit, Ates, Impullitti (2017)
Illustration of the Innovation Dynamics

Suppose the follower in line 2 innovates.

- Scenario 2: It catches up.
Illustration of the Innovation Dynamics

Suppose the follower in line 2 innovates.

- Scenario 3: It leapfrogs.
Illustration of the Innovation Dynamics

Entry leads to similar dynamics ...

- ... but forces the domestic incumbent to exit.

quality, q

entrants

Akcigit, Ates, Impullitti (2017)
Illustration of the Innovation Dynamics

Entry leads to similar dynamics ...

- Scenario 1: It closes the gap, but remains follower.
Illustration of the Innovation Dynamics

Entry leads to similar dynamics ...

- Scenario 2: It catches up.
Illustration of the Innovation Dynamics

Entry leads to similar dynamics ...

- Scenario 3: It leapfrogs.

quality, q

entry

exit

line 1 line 2 line 3 line 4 line 5

US FN

product line, j

Akcigit, Ates, Impullitti (2017)
Free Entry

\[ m = \bar{m} \]

\[ m = 1 \]

\[ m = 0 \]

\[ m = -1 \]

\[ m = -\bar{m} \]
\[ \tilde{x}_{-\bar{m}}^A \rightarrow m = -\bar{m} \]

\[ \tilde{x}_0^A \rightarrow m = 0 \]

\[ \tilde{x}_1^A \rightarrow m = 1 \]

\[ \tilde{x}_{\bar{m}}^A \rightarrow m = \bar{m} \]
Value Functions

\[ r_{At} V_{Amt} (q_t) - \dot{V}_{Amt} (q_t) = \max_{x_{Amt}} \left\{ \Pi (m) q_t - \left( 1 - \tau^A \right) \alpha_A \frac{(x_{Amt})^{\gamma_A}}{\gamma_A} q_t \right. \]

\[ + x_{Amt} \sum_{n_t = m+1}^{m} \mathbb{F}_m (n_t) \left[ V_{Amt} \left( \lambda^{(n_t-m)} q_t \right) - V_{Amt} (q_t) \right] \]

\[ + \tilde{x}_{Amt} \left[ 0 - V_{Amt} (q_t) \right] \]

\[ + (x_{B(-m)t} + \tilde{x}_{B(-m)t}) \sum_{n_t = -m+1}^{\bar{m}} \mathbb{F}_{-m} (n_t) \left[ V_{A(-nt)} (q_t) - V_{Amt} (q_t) \right] \]
Quantitative Analysis

Part 1. Estimation
Calibration strategy

- 17 parameters to be determined, 7 are estimated
  - 6 statistics on trade, growth, and innovation over 1975-81 ...
  - and the leadership distribution in 1981.

- Initiate the model in 1975 feeding in the leadership distribution and simulate until 1981

### Table: Model fit

| Moment               | Estimate | Target | Source                          |
|----------------------|----------|--------|---------------------------------|
| 1. TFP Growth U.S.   | 0.45%    | 0.55%  | Coe et al. (2009) 1975-81       |
| 2. TFP Growth FN     | 2.13%    | 1.82%  | Coe et al. (2009) 1975-81       |
| 3. R&D/GDP U.S.      | 1.65%    | 1.75%  | OECD 1981                       |
| 4. R&D/GDP FN        | 1.85%    | 1.96%  | OECD 1981                       |
| 5. Entry Rate U.S.   | 10%      | 10%    | BDS 1977-81                     |
| 6. Export Share U.S. | 7.11%    | 7%     | WB 1975-81                      |
| 7. Patenting Distribution | n/a   | n/a    | See next slide.                |
Identification: Evolution of Sector Shares

Model replicates adverse shift of leadership distribution toward smaller gaps over 1975-85.

Akcigit, Ates, Impullitti (2017)
Validation I: Steady-state Innovation Distribution

Figure. Data (left) vs Model Simulation (right)

In our simulation, \( m^* \approx 10 \).
Validation II: Implications on Entrant Innovation

Innovation and Trade Policy in a Globalized World

Figure 12: Entrant innovation intensity

The decisions of firms to innovate and to enter the export market. They found that these two decisions are highly correlated, that is firms entering the export market are more likely to also speed up their investment in R&D. Lileeva and Trefler (2010) find that Canadian plants that were induced by the U.S. tariff cuts to start exporting (a) increased their labor productivity, (b) engaged in more product innovation, and (c) had higher adoption rates for advanced manufacturing technologies.

Foreign catching up.

Improvements in a country's trade partners' technology is a mode of globalization that has received less attention in the literature than the reduction of trade and offshoring barriers. We now explore the impact on a country's welfare of foreign technological catching up. First, Figure 13 shows the resulting behavior of profits along the transition for the 1975-1981 period. Profits generated by each country's leading firms show a clear convergence trend. This is driven by the international business-stealing effect, whereby foreign firms progressively capture leadership in more markets and formerly collected profits by the U.S. firms are now collected by the foreign firms. This business-stealing effect is crucial in shaping the welfare effects of foreign catching up to which we turn next.

For understanding the welfare effects of foreign convergence it proves useful to create a counterfactual economy where we shut down foreign business stealing. In this new setup foreign firms are allowed to innovate, however, whenever the step size of a new innovation allows them to steal the market of the U.S. competitor, we exogenously assume that the step size can only get close to the highest level that avoid capturing the profits of the competitor. For example, suppose a foreign incumbent serves only its domestic market, and to export, it needs to open the gap size between itself and its U.S. competitor by three gaps. Suppose this foreign firm receives an innovation that would make it jump four steps. In this case, we bound the step size to two so

Figure. Entrant Innovation. Model (left) vs data (right).
Quantitative Analysis

Part 2. Welfare Implications and Optimal Policy
Welfare Effects of Catching-Up

Table 8: Observed and optimal U.S. R&D subsidy: 1981-2016

| Subsidy rate          | Welfare gains 1981-2016 |
|-----------------------|--------------------------|
| Observed R&D subsidy  | 19.2%                    | 0.77%                     |
| Optimal R&D subsidy   | 69%                      | 5.8%                      |
Welfare Effects of Protectionist Policies

Question:

► What is the impact of a 40% increase in tariffs on welfare and innovation?
Questions:

- What is the impact of a 40% increase in tariffs on welfare and innovation?

Welfare (left) and innovation response (right) after 40% tariff rate.
Welfare Effects of Protectionist Policies

Question:

- What is the optimal tariff rate for different policy horizons?
Welfare Effects of Protectionist Policies

Question:

▶ What is the optimal tariff rate for different policy horizons?

Akcigit, Ates, Impullitti (2017)
Question:

- What is the optimal tariff rate for different policy horizons?
Optimal Subsidy Policy

Questions:
1. What is the optimal subsidy rate for different time horizons?
2. How does it depend on openness?
Optimal Subsidy Policy

Questions:
1. What is the optimal subsidy rate for different time horizons?
2. How does it depend on openness?

![Graph showing the relationship between horizon in years and optimal subsidy rate.]

![Graph showing the relationship between change in openness and optimal subsidy rate.]

Akcigit, Ates, Impullitti (2017)
Conclusion

- Built a new dynamic general equilibrium model with endogenous productivity growth, international trade and strategic interaction between competing firms.

- Strategic interaction (competition) channel is quantitatively very important.

- Policies have different implications in different horizons:
  - Protectionist response, short-run gains, long-run losses
  - R&D subsidy leads to notable welfare gains in longer horizons

- Governing globalization? Yes but with innovation policy, not protectionism!

- To do: Brexit simulation?