Innovation and Trade Policy in a Globalized World

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Motivation - United States in the Late 1970s

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)\textsuperscript{a}

\textsuperscript{a} Associate Director of the Office of Science and Technology Policy of the Reagan Administration.
“... 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.”


Akcigit, Ates, Impullitti (2017)
Make America Great Again!

Introduction of federal R&D tax credit (ERTA)

US Share in Total Patents (dashed)

R&D/Sales (solid)

Year


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

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

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

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

The diagram illustrates the relationship between the technological gap between domestic and foreign firms and innovation effort. The graph shows how the protectionist pressure towards foreign firms changes with the technological gap.

**Legend:**
- Blue line: Incumbent innovation US

**Axes:**
- Y-axis: Innovation effort
- X-axis: Technological gap btw. domestic and foreign firms

**Graph Sections:**
- Import
- No Trade
- Export

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

Technological gap btw. domestic and foreign firms

Innovation effort

Incumbent innovation US

Protectionism

Import

No Trade

Export

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

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

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

- **Incumbent innovation US**
- **Protectionism**

**Technological gap btw. domestic and foreign firms**

- **Import**
- **No Trade**
- **Export**

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

Retaliation:

Technological gap btw. domestic and foreign firms

Innovation effort

Incumbent innovation US
Protectionism

Technological gap btw. domestic and foreign firms

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

R&D Subsidy:

Akcigit, Ates, Impullitti (2017)
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

Akcigit, Ates, Impullitti (2017)
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

\[
A_c(t) = \int_0^1 (V_{cj}(t) + \tilde{V}_{cj}(t))dj.
\]
There is a representative household in each country:

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

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

Budget constraint

\[ r_c A_c + L_c \omega_c = C_c + \dot{A}_c + T_c, \]  \hspace{1cm} (2)

Asset markets

\[ A_c = \int_{0}^{1} (V_{cj} + \tilde{V}_{cj}) dj. \]
Final Good

Final good in country \( c \) produced with technology

\[
Y_c = \frac{L_c^\beta}{1 - \beta} \int_0^1 q_{c'j}^{\beta} k_{c'j}^{1-\beta} dj, \text{ where } c' \in A, B
\]  (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 $\kappa$. 

Akcigit, Ates, Impullitti (2017)
Final Good producer’s maximization gives

\[ p_j = q_j^\beta k_j^{1-\beta}. \]

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

► Equilibrium profit from selling abroad is:

\[ \hat{\Pi}(q_j) = \hat{\pi} q_j, \]

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

\[ \pi \]

Product line, \( j \)

H1

H2

US firms, when sold at home

\( \pi q \)
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

\[
\pi q
\]

Product line, \( j \)

US firms, when sold at home

US firms, when sold abroad

Akcigit, Ates, Impullitti (2017)
Decision to Trade

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

$\pi q$

$H_1$, $H_2$: US firms, when sold at home

$H_1'$, $H_2'$: US firms, when sold abroad

0 1

Export Domestic sale only Import

Akcigit, Ates, Impullitti (2017)
Thus, the comparison between incomes in autarky and the open economy boils down to the comparison of
\[ \int_0^1 q_{cj} dj \] and
\[ (1 + (1 + \kappa) - \beta - \beta) \int_0^1 q_{cj} dj > \hat{q}_j^* q_{cj} dj \]
determining the profit component, and to the comparison of
\[ \int_0^1 q_{cj} dj \] and
\[ \int_0^1 I q_{cj} dj > \hat{q}_j^* q_{cj} dj + (1 + \kappa) - \beta \beta \int_0^1 [1 - I q_{cj} dj] \hat{q}_j^* dj \]
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.

Figure 9: Static effects of openness

First, compared to the state of autarky, the open economy allows relatively more productive firms to sell to a larger market, by providing the opportunity to export. This positive effect of market size on aggregate income is evident from the first component in equation (20), as profits of leading firms increase proportionally by \( \pi^* \). This increase corresponds to the upward expansion of the red line in Figure 9a, determined by the additional income from exporting. Note that the
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 \( \bar{m} \)  
  
  \[
  m_c \in \{-\bar{m}, -\bar{m} + 1, \ldots, 0, \ldots, \bar{m} - 1, \bar{m}\}, \text{ where } c \in \{A, B\}
  \]

- \( F(k) \) 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, $F(k)$

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

For $n \in [m+1, \bar{m}]$,

$$F_m(n) = F_{-\tilde{m}}(n)$$
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:

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

- **Incumbents:**
  \[ C \left( x^c_j; q_j \right) = q_j \alpha_c \left( x^c_j \right)^{\gamma_c} . \]
  - \( z^c_j \): R&D investment
  - \( x^c_j \): Poisson arrival rate:

- **Entrants:**
  \[ C \left( \tilde{x}^c_j; q_j \right) = q_j \alpha_c \left( \tilde{x}^c_j \right)^{\gamma_c} . \]
  - 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.
Illustration of the Innovation Dynamics

Suppose the follower in line 2 innovates.

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

Entry leads to similar dynamics ...

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

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

Entry leads to similar dynamics ...

- Scenario 2: It catches up.

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

Entry leads to similar dynamics ...

- Scenario 3: It leapfrogs.

\[
\text{quality, } q
\]

\begin{figure}
\centering
\includegraphics[width=\textwidth]{diagram}
\caption{Diagram illustrating the dynamics of entry and exit in a product line.}
\end{figure}

Akçigit, Ates, Impullitti (2017)
\[ m = \bar{m} \]
\[ m = 1 \]
\[ m = 0 \]
\[ m = -1 \]
\[ m = -\bar{m} \]
Free Entry

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

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

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

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

\[ \tilde{x}_{-\bar{m}}^{A} \rightarrow m = -\bar{m} \]
\[ r_{At} V_{Amt} (q_t) - \dot{V}_{Amt} (q_t) = \max_{x_{Amt}} \left\{ \Pi (m) q_t - \left( 1 - \tau^A \right) \alpha_A \frac{x_{Amt}^{\gamma A}}{\gamma_A} q_t \\
+ x_{Amt} \sum_{n_t = m+1}^{\bar{m}} \mathbb{F}_m (n_t) \left[ V_{Amt} \left( \lambda^{(n_t-m)} q_t \right) - V_{Amt} (q_t) \right] \\
+ \tilde{x}_{Amt} [0 - V_{Amt} (q_t)] \\
+ (x_{B(-m)t} + \tilde{x}_{B(-m)t}) \sum_{n_t = -m+1}^{\bar{m}} \mathbb{F}_{-m} (n_t) \left[ V_{A(-nt)} (q_t) - V_{Amt} (q_t) \right] \right\} \]
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>
<thead>
<tr>
<th>Table: Model fit</th>
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<tbody>
<tr>
<td><strong>Moment</strong></td>
</tr>
<tr>
<td>1. TFP Growth U.S.</td>
</tr>
<tr>
<td>2. TFP Growth FN</td>
</tr>
<tr>
<td>3. R&amp;D/GDP U.S.</td>
</tr>
<tr>
<td>4. R&amp;D/GDP FN</td>
</tr>
<tr>
<td>5. Entry Rate U.S.</td>
</tr>
<tr>
<td>6. Export Share U.S.</td>
</tr>
<tr>
<td>7. Patenting Distribution</td>
</tr>
</tbody>
</table>
Model replicates adverse shift of leadership distribution toward smaller gaps over 1975-85.
Validation I: Steady-state Innovation Distribution

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

In our simulation, $m^* \approx 10$. 

Akcigit, Ates, Impullitti (2017)
Validation II: Implications on Entrant Innovation

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

Akcigit, Ates, Impullitti (2017)
Quantitative Analysis

Part 2. Welfare Implications and Optimal Policy
Although U.S. policy makers went in the right direction by increasing the subsidy rate as foreign catching up was accelerating in the 1980s, they did not go far enough. The optimal subsidy response to increasing foreign technological competition suggests that the subsidy rate should have been about 70%, more than three times higher than the observed one. This high subsidy would have increased welfare by a striking 5.8% every year in the 35-year period considered. Moreover, we have also calculated the optimal subsidy for shorter time horizons and we find that the observed post-81 subsidy is only optimal for a time horizon of about 8 years.

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

<table>
<thead>
<tr>
<th></th>
<th>Subsidy rate</th>
<th>Welfare gains 1981-2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed R&amp;D subsidy</td>
<td>19.2%</td>
<td>0.77%</td>
</tr>
<tr>
<td>Optimal R&amp;D subsidy</td>
<td>69%</td>
<td>5.8%</td>
</tr>
</tbody>
</table>
Welfare Effects of Protectionist Policies

Question:

▶ What is the impact of a 40% increase in tariffs on welfare and innovation?
Welfare Effects of Protectionist Policies

Questions:

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

![Graph showing welfare and innovation response](image)

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**?

![Graph showing the relationship between horizon in years and optimal tariff rate.](attachment:image.png)
Welfare Effects of Protectionist Policies

Question:

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

![Graph showing the relationship between optimal tariff rate and horizon in years.](image-url)
Optimal Subsidy Policy

Questions:

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

![Graph showing optimal subsidy rate vs. horizon in years and change in openness](image)
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?

Akcigit, Ates, Impullitti (2017)