INNOVATION AND TRADE POLICY IN A GLOBALIZED WORLD

Ufuk Akcigit  
U. of Chicago

Sînâ T. Ateş  
Federal Reserve Board

Giammario Impullitti  
U. of Nottingham

CompNet-EBRD Workshop  
09/10/2018

†The views expressed here are those of the authors and do not necessarily reflect those of the Board of Governors or the Federal Reserve System.
Motivation - United States in the Late 1970s

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

Labor Productivity Growth in Manufacturing
(output/hour, in %, 1976-80 avg.)
“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.
Make America Great Again!

Numbers above bars denote number of states with R&D tax credit. Abbreviations refer to names of states with positive R&D tax credit.
Source: Authors’ calculations, Wilson (2009)
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Introduction of R&D tax credit (ERTA)

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— R&D Intensity
Make America Great Again!

Introduction of R&D tax credit (ERTA)

Number of states with R&D tax credit:
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

Abbreviations refer to names of states with positive R&D tax credit.
Source: Authors’ calculations, Wilson (2009)

— R&D Intensity — — Patenting Share of the U.S.
R&D Policies in Other Countries

R&D subsidies were prominent only in the U.S.
Motivating Questions

1. What are the welfare effects of industrial policies in an open economy faced with foreign technological competition?
   - Protectionism vs. R&D subsidies

2. How do the implications depend on the policymaker’s horizon?
   - Short run vs. Long run

A good framework should also incorporate the non-monotonic empirical link between import competition and innovation as in Bloom et al. (2016) and Autor et al. (2016), among many others.
Motivating Questions

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To Answer These Questions...

1. **New Micro Evidence**

2. **Model**
   - Two large open economies subject to trade frictions
   - Dynamic general equilibrium with endogenous incumbent innovation
   - Step-by-step innovation with strategic interaction between firms
   - Endogenous entry-exit of firms
   - Transitional dynamics: important for policy horizon

3. **Quantitative Policy Analysis**
   - Evaluate policies in different policy horizons
     - One-sided trade policy
     - Incumbent R&D subsidy
     - Two-sided trade policy (retaliation)
     - Optimal policies
Main Mechanism in the Model

Technological gap btw. domestic and foreign firms

Innovation effort

Incumbent innovation US

Protectionism

R&D subsidy
Main Mechanism in the Model

![Graph showing Technological gap btw. domestic and foreign firms vs. Innovation effort. The graph is split by a dotted line at 0, indicating a threshold between Import and Export. The y-axis represents Innovation effort, ranging from 0.2 to 1.2, while the x-axis represents Technological gap btw. domestic and foreign firms, ranging from -15 to 15.]
Main Mechanism in the Model

Technological gap btw. domestic and foreign firms

Innovation effort

Incumbent innovation US

Protectionism

R&D subsidy

Import

Export
Main Mechanism in the Model

- Technological gap btw. domestic and foreign firms
- Innovation effort
- Incumbent innovation US
- Protectionism
- Import
- No Trade
- Export
- R&D subsidy
- Retaliation
Main Mechanism in the Model

The graph illustrates the relationship between technological gaps between domestic and foreign firms and innovation efforts. It shows how changes in protectionism and R&D subsidies impact these gaps.

- **Protectionism**: Decreases innovation efforts, as indicated by the steep decline in the graph.
- **R&D Subsidy**: Increases innovation efforts, as shown by the peak in the graph.

The graph also highlights the impact on trade scenarios:
- **Import**: Decreases technological gaps and innovation efforts.
- **Export**: Increases technological gaps and innovation efforts.
- **No Trade**: Indicates a balanced scenario with minimal changes in technological gaps and innovation efforts.
Main Mechanism in the Model

- **Defensive R&D**
- **Expansionary R&D**

### Technological gap btw. domestic and foreign firms

<table>
<thead>
<tr>
<th>Technological gap</th>
<th>Innovation effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15</td>
<td>0.1</td>
</tr>
<tr>
<td>-10</td>
<td>0.2</td>
</tr>
<tr>
<td>-5</td>
<td>0.3</td>
</tr>
<tr>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>0.6</td>
</tr>
<tr>
<td>15</td>
<td>0.7</td>
</tr>
</tbody>
</table>

### Innovation effort

- **Incumbent innovation US**
- **Protectionism**
- **R&D subsidy**

### Trade scenarios

- **Import**
- **No Trade**
- **Export**
Main Mechanism in the Model

**PROTECTIONISM**

The diagram illustrates the impact of protectionism on innovation effort in the model. The x-axis represents the technological gap between domestic and foreign firms, while the y-axis shows innovation effort. The blue line represents incumbent innovation in the US, and the orange line represents protectionism. The graph shows how protectionism affects innovation differently depending on the technological gap and the trade status (Import, No Trade, Export).
Main Mechanism in the Model

PROTECTIONISM

- Technological gap btw. domestic and foreign firms
- Innovation effort
- Incumbent innovation US
- Protectionism
- Import
- No Trade
- Export
Main Mechanism in the Model

**RETALIATION**

![Graph showing the relationship between technological gap and innovation effort. The graph indicates a peak in innovation effort at a certain technological gap, highlighting the role of retaliation in this relationship.]
Main Mechanism in the Model

R&D SUBSIDY

![Graph showing the main mechanism in the model with R&D subsidy. The graph plots innovation effort against the technological gap between domestic and foreign firms.]
Preview of the Results

1. **Static effects:**
   - Protectionism "could potentially" benefit the domestic economy.
   - → profit shifting

2. **Dynamic effects:**
   - Openness leads more innovation through competition:
     - Domestic market: defensive innovation
     - Foreign market: expansionary innovation
   - Openness → Technology transfer, spillover

3. **Protectionism:** Welfare gains only if it is
   - one sided, AND, in the short run (up to 20 yrs.)

4. **R&D subsidies:** Dominant policy for long-sighted policy makers

5. **Policy complementarity:** Globalization → less need for policy intervention (markets would take care of themselves).

6. **Optimal policy mix:** The interplay with retaliatory response
MODEL

Part 1. Static Environment
Preferences and Final Good

- Final good in country $c$ produced with technology

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

  - $L_c$: Fixed factor, immobile, normalized to 1.
  - $q_{cj}$: quality of variety $j$ in country $c$
  - $k_{cj}$: amount of variety $j$ used.

- Implies that the highest quality good (adjusted for trade cost) is purchased.

- Final good producer’$s$ maximization gives:

$$p_j = q_j^\beta k_j^{-\beta}.$$
Intermediate Goods - production

Model Economy
Intermediate Goods - production

Model Economy

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

Tech. Leadership in $j = \begin{cases} 
US \text{ is leader,} & \text{if } q_{US,j} > q_{FN,j} \\
FN \text{ is leader,} & \text{if } q_{US,j} < q_{FN,j} \\
\text{Neck&Neck,} & \text{if } q_{US,j} = q_{FN,j}
\end{cases}$
Intermediate Goods - production

Model Economy

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

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

$$\Pi (q_j) = \max_{k_j \geq 0} \left\{ q_j^\beta k_j^{1-\beta} - \eta k_j \right\}.$$ 

**Robustness I:** Labor in the intermediate good production.
Intermediate Goods - production

Model Economy

Selling abroad has export (iceberg) cost $\kappa$ and subject to tariff $\tau^{FN}$.

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

Robustness II: Tariff revenue transferred back to the HH.
Model Economy

Resulting equilibrium profits:

Profit in the domestic market: \( \Pi (q_j) = \left( \frac{1 - \beta}{\eta} \right)^{\frac{1-\beta}{\beta}} \beta q_j \)

Profit in the foreign market: \( \hat{\Pi} (q_j) = \left( \frac{1 - \beta}{(1 + \kappa + \tau^{FN})\eta} \right)^{\frac{1-\beta}{\beta}} \beta q_j \)
Export vs. Import Decisions

Actual market ownership depends on technological leadership and trade costs:

- US exports in sector $j$ iff

  $$\frac{q_{USj}}{q_{FNj}} > (1 + \kappa) \left( \frac{1+\beta}{\beta} \right)$$

- US imports in sector $j$ iff

  $$\frac{q_{FNj}}{q_{USj}} > (1 + \kappa) \left( \frac{1+\beta}{\beta} \right)$$
Export vs. Import Decisions

Actual market ownership depends on *technological leadership* and *trade costs*:

- US exports in sector $j$ iff

\[
\frac{q_{USj}}{q_{FNj}} > (1 + \kappa) \frac{(1+\beta)}{\beta} \quad \text{if } \kappa > 0
\]

- US imports in sector $j$ iff

\[
\frac{q_{FNj}}{q_{USj}} > (1 + \kappa) \frac{(1+\beta)}{\beta}
\]
MODEL

Part 2. Dynamic Environment
Intermediate Goods - innovation

רג落ちת phẩmה מתפתחת דרך איננואציה וסיפלורזס.

 Reggie תוספת איננואציה יוצרת קפיצות איכותיות בין t וt + Δt :

\[ q_{cj}(t + Δt) = λ^n q_{cj}(t) \]

מה \( λ > 1 \), \( c \in \{US, FN\} \), ו- \( n \in \mathbb{N}^+ \) היא משתנה החance.

 Reggie טכנולוגיהunkt בין US וFN ב- j:

\[ \frac{q_{USj}}{q_{FNj}} = λ^{N_{USj} - N_{FNj}} \equiv λ^{m_j} \]

 Reggie אנשופט. מקסימום הunkt הוא \( \bar{m} \):

\[ m_j \in \{-\bar{m}, ..., -1, 0, 1, ..., \bar{m}\} \]
Suppose the follower in line 2 innovates.

Scenario 3: It leapfrogs.
Suppose the follower in line 2 innovates.

- Scenario 1: It closes the gap, but remains follower.
Suppose the follower in line 2 innovates.

- Scenario 2: It catches up.
Suppose the follower in line 2 innovates.

- Scenario 3: It leapfrogs.
Free entry leads to similar dynamics ... ▶... but forces the domestic incumbent to exit.
Free entry leads to similar dynamics ...

- Scenario 1: It closes the gap, but remains follower.
Free entry leads to similar dynamics ...

- Scenario 2: It catches up.
Free entry leads to similar dynamics ...

- Scenario 3: It leapfrogs.
Step Jump Distribution, $\mathbb{F}(n)$

Recall: $q_{cj}(t + \Delta t) = \lambda^n q_{cj}(t)$, with $n \sim \mathbb{F}(n)$. $\mathbb{F}(n)$ 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)]
Innovation Decision and Industrial Policy

4 main determinants of innovation incentives:

1. Expansion to new markets
2. Defense of domestic markets
3. Quality/profit improvement
4. Spillovers
Innovation Decision and Industrial Policy

Policies affect these incentives through different channels:

1. **Tariffs** and the profit channel:

\[
\hat{\Pi}(q_{jt} | m, \tau^{US}, \tau^{FN}) = \left( \frac{1 - \beta}{(1 + \kappa + \tau^{FN})\eta} \right)^{\frac{1-\beta}{\beta}} \beta q_{jt}
\]

2. **R&D subsidies** and the cost channel:

\[
C(x_{mt}^{US} | s^{US}) = \left( 1 - s^{US} \right) \alpha_{US} \left( x_{mt}^{US} \right)^{\gamma_{US}} q_{jt}
\]
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.

<table>
<thead>
<tr>
<th>Moment</th>
<th>Estimate</th>
<th>Target</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TFP Growth U.S.</td>
<td>0.45%</td>
<td>0.55%</td>
<td>Coe et al. (2009) 1975-81</td>
</tr>
<tr>
<td>2. TFP Growth FN</td>
<td>2.13%</td>
<td>1.82%</td>
<td>Coe et al. (2009) 1975-81</td>
</tr>
<tr>
<td>3. R&amp;D/GDP U.S.</td>
<td>1.65%</td>
<td>1.75%</td>
<td>OECD 1981</td>
</tr>
<tr>
<td>4. R&amp;D/GDP FN</td>
<td>1.85%</td>
<td>1.96%</td>
<td>OECD 1981</td>
</tr>
<tr>
<td>5. Entry Rate U.S.</td>
<td>10%</td>
<td>10%</td>
<td>BDS 1977-81</td>
</tr>
<tr>
<td>6. Export Share U.S.</td>
<td>7.11%</td>
<td>7%</td>
<td>WB 1975-81</td>
</tr>
<tr>
<td>7. Tech Gap Distribution</td>
<td>n/a</td>
<td>n/a</td>
<td>See next slide.</td>
</tr>
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Patent Classes to Technology Gaps

**Patent Classes**

- A01B
- A61K
- B02C
- E21B
- F04B

400+ sectors

# US patents

- 0.50
- 0.02
- 0.46
- 0.98
- 0.53

# total

- 0.03
- 0.48
- 0.51
- 0.54
- \(m = \bar{m} = 16\)

- 0
- 1
- \(m = \bar{m} = 1\)

- 1
Patent Classes to Technology Gaps

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Tech. gaps/bins

- \(m = \bar{m} = 16\)
- \(m = 1\)
- \(m = 0\)
- \(m = -1\)
- \(m = -\bar{m} = -16\)
# Patent Classes to Technology Gaps

## Patent Classes

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## Tech. gaps/bins

- $m = \bar{m} = 16$
- $m = 1$
- $m = 0$
- $m = -1$
- $m = -\bar{m} = -16$
Initiate the model in 1975 feeding in the leadership distribution ...
Identification: Evolution of Sector Shares

- ... and simulate until 1981.
Model replicates the adverse shift of leadership distribution toward smaller gaps over 1975-85.
Quantitative Analysis

Part 2. Validation of the Model
Validation I: Steady-state Innovation Distribution

**Figure:** Incumbent innovation effort and leadership

In our simulation, estimated $m^* = 11$. 
Validation I: Steady-state Innovation Distribution

**Figure:** Incumbent innovation effort and leadership

In our simulation, estimated $m^* = 11$. 
Validation II: Trade Cost Reduction

**A) Tariffs**

*Figure:* Tariffs and incumbents’ innovation intensity in manufacturing

*Data support the model prediction: lower trade barriers make the peaks shift inward.*
Validation II: Trade Cost Reduction

**Figure**: Tariffs and incumbents’ innovation intensity in manufacturing

Data support the model prediction: lower trade barriers make the peaks shift inward.
Validation III: Implications on Entrant Innovation

**A) Model**

![Graph A: Entrant innovation US](image1)

**B) Data**

![Graph B: Patent entry rate by sector](image2)

**Figure:** Entrant innovation effort and leadership
Quantitative Analysis

Part 3. Welfare Implications and Optimal Policy
**Welfare Effects of Catching-Up**

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

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<td>19.2%</td>
<td>0.87%</td>
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<tr>
<td>Optimal R&amp;D subsidy</td>
<td>66%</td>
<td>5.49%</td>
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Observed policy is optimal when a horizon of only 5 years considered.
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*Observed policy is optimal when a horizon of only 5 years considered.*
Welfare Effects of Protectionist Policies

Q1. What is the effect of a 20% increase in tariffs on welfare?
Q2. What is the effect of a 20% increase in tariffs on innovation?
Welfare Effects of Protectionist Policies

Q1. What is the effect of a 20% increase in tariffs on welfare?
Q2. What is the effect of a 20% increase in tariffs on innovation?

\[ \text{Percentage of Protection} \]

A) Consumption equivalent welfare

One-sided tariff generates welfare gains in the short-run (\(< 20\) years) and welfare losses in longer horizons.
Welfare Effects of Protectionist Policies

Q1. What is the effect of a 20% increase in tariffs on welfare?
Q2. What is the effect of a 20% increase in tariffs on innovation?

A) Consumption equivalent welfare

This is due to reduced defensive innovation incentives.

b) Innovation response of incumbents
Welfare Effects of Protectionist Policies

Q1. What is the optimal tariff rate for different time horizons?
Welfare Effects of Protectionist Policies

Q1. What is the optimal tariff rate for different time horizons?

Status quo is optimal if the policy horizon is $\approx 25$ years.
Optimal Subsidy Policy

Q1. What is the optimal subsidy rate for different time horizons?
Q2. How does it depend on the degree of openness?
Optimal Subsidy Policy

Q1. What is the **optimal subsidy rate** for different **time horizons**?
Q2. How does it depend on the **degree of openness**?

A) Over different horizons

*The longer the policymaker’s horizon is, the more aggressive is the optimal policy.*
Optimal Subsidy Policy

Q1. What is the optimal subsidy rate for different time horizons?

Q2. How does it depend on the degree of openness?

A) Over different horizons

b) Over openness (fixed horizon of 35 years)

The more open the world markets are, the less aggressive is the optimal policy.
Extensions and Robustness

- Quantifying the welfare impact of protectionism on foreign country.
- Optimal policy mix.
- Effect of retaliation.
- Labor in the intermediate good production.
- Tariff revenue consumed by the household.
- Alternative values for $\bar{m}$. 
Quantitative Analysis

Part 4. Impact of Import Competition on Incumbent Innovation
Import Competition and Innovation

The empirical literature on trade and innovation has documented conflicting (!) results:

**Import ↑ innovation**
- Bloom, Draca, and Van Reenen (2016),
- Gorodnichenko, Svejnar, and Terrell (2010),
- Iacovone (2012),
- Coelli, Moxnes, and Ulltveit-Moe (2016),
- Fernandes (2007)

**Import ↓ innovation**
- Autor, Dorn, Hanson, Pisano, and Shu (2016)
- Gilbert (2006),
- Hashmi (2013),
- Hombert and Matray (2015),

**Mixed results**
- Chen and Steinwender (2016)
- Aghion, Bergeaud, Lequien, and Melitz (2017)
How does our model reconcile these?

- How can our model speak to these conflicting results?
- Assume a 50% one-sided reduction in tariffs.
- This increases competition on the import margin ...
- ... and changes the sectors that face intensified competition.
50% Reduction in Tariffs

Innovation: reduction in most laggard sectors, increase in less inferior ones
50% Reduction in Tariffs

Innovation: reduction in most laggard sectors, increase in less inferior ones

⇒ Sectoral composition matters for the overall effect on innovation!
How does our model reconcile these?
How does our model reconcile these?
How does our model reconcile these?

Different Initial Distributions

Technological gaps btw. domestic and foreign firms
How does our model reconcile these?

More innovation gains for more advanced economies?
How does our model reconcile these?

Different Initial Distributions
How does our model reconcile these?

Different Initial Distributions

+0.52%
+5.45%

Technological gaps btw. domestic and foreign firms

Not necessarily! It depends on the sectoral composition.
How does our model reconcile these?

**Different Initial Distributions**

- Technological gaps btw. domestic and foreign firms
- +0.52%
- +5.45%
How does our model reconcile these?

Even an advanced country can get hurt!
Conclusion

- Built a new DGE 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!

- Application: Lessons for Brexit?
APPENDIX
“... 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.”

Technology

\[ Y_{ct} = \frac{L_c^\beta}{1 - \beta} \int_0^1 \left( \frac{\beta}{q_{Ajt}} k_{Ajt} + \frac{\beta}{q_{Bjt}} k_{Bjt} \right)^{1-\beta} dj. \]
Value Functions

Determinants of Innovation Decisions and Industrial Policy

\[
\begin{align*}
\dot{V}_{US,mt} (q_t) - \ddot{V}_{US,mt} (q_t) \\
= \max_{x_{US,mt}} \left\{ \Pi \left( m; \tau^{US}, \tau^{FN} \right) q_t - \left( 1 - s^{US} \right) \alpha_{US} \frac{(x_{US,mt})^{\gamma_{US}}}{\gamma_{US}} q_t \\
+ x_{US,mt} \sum_{n_t=m+1}^{\bar{m}} \mathcal{I} F_m (n_t) \left[ V_{US,nt} \left( \lambda^{(n_t-m)} q_t \right) - V_{US,mt} (q_t) \right] \\
+ \tilde{x}_{US,mt} \left[ 0 - V_{US,mt} (q_t) \right] \\
+ \left( x_{FN(-m)t} + \tilde{x}_{FN(-m)t} \right) \sum_{n_t=-m+1}^{\bar{m}} \mathcal{I} F_{-m} (n_t) \left[ V_{US(-nt)} (q_t) - V_{US,mt} (q_t) \right] \right\}
\end{align*}
\]

\[x_{US,mt}: \text{Domestic incumbent innovation}\]
\[\tilde{x}_{US,mt}: \text{Domestic entrant innovation}\]
\[x_{FN,mt}: \text{Foreign incumbent innovation}\]
\[\tilde{x}_{FN,mt}: \text{Foreign entrant innovation}\]
Value Functions

Determinants of Innovation Decisions and Industrial Policy

\[ r_{US,t} V_{US,mt} (q_t) - \dot{V}_{US,mt} (q_t) \]

\[ = \max_{x_{US,mt}} \left\{ \Pi \left( m; \tau^{US}, \tau^{FN} \right) q_t - (1 - s^{US}) \alpha_{US} \frac{(x_{US,mt})^{\gamma_{US}}}{\gamma_{US}} q_t \right. \]

\[ + x_{US,mt} \sum_{n_t=m+1}^{\bar{m}} F_m (n_t) \left[ V_{US,nt} \left( \lambda^{(n_t-m)} q_t \right) - V_{US,mt} (q_t) \right] \]

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

\[ + \left( x_{FN(-m)t} + \tilde{x}_{FN(-m)t} \right) \sum_{n_t=-m+1}^{\bar{m}} F_{-m} (n_t) \left[ V_{US(-nt)} (q_t) - V_{US,mt} (q_t) \right] \} \]

\[ x_{US,mt}: \text{Domestic incumbent innovation} \]

\[ \tilde{x}_{US,mt}: \text{Domestic entrant innovation} \]

\[ x_{FN,mt}: \text{Foreign incumbent innovation} \]

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Value Functions

Determinants of Innovation Decisions and Industrial Policy

\[
\begin{align*}
\hspace{1cm} & r_{US,t}V_{US,mt}(q_t) - \dot{V}_{US,mt}(q_t) \\
= & \max_{x_{US,mt}} \left\{ \Pi \left( m; \tau^{US}, \tau^{FN} \right) q_t - \left( 1 - s^{US} \right) \alpha_{US} \frac{(x_{US,mt})^{\gamma_{US}}}{\gamma_{US}} q_t \\
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& + \tilde{x}_{US,mt} \left[ 0 - V_{US,mt}(q_t) \right] \\
& + \left( x_{FN(-m)t} + \tilde{x}_{FN(-m)t} \right) \sum_{n_t=-m+1}^{\bar{m}} F_{-m}(n_t) \left[ V_{US(-nt)}(q_t) - V_{US,mt}(q_t) \right] \right\}
\end{align*}
\]

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\[ r_{US,t} V_{US,mt} \left( q_t \right) - \dot{V}_{US,mt} \left( q_t \right) \]

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\[ + x_{US,mt} \sum_{n_t=m+1}^{\bar{m}} F_m \left( n_t \right) \left[ V_{US,nt} \left( \lambda^{(n_t-m)} q_t \right) - V_{US,mt} \left( q_t \right) \right] \]

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External Calibration

<table>
<thead>
<tr>
<th>Table: Externally Calibrated Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi$</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

- $\psi$: Utility parameter, standard macro value.
- $\gamma, \tilde{\gamma}$: Quadratic convex cost, large R&D literature (Akcigit and Kerr, 2017).
- $\beta$: Production function parameter, 70% labor share.
- $\eta$: Marginal cost of production, set $\eta = 1 - \beta$ for tractability.
- $\rho$: Standard discount rate, imply 2.8% interest rate in steady state.
**Table: Internally Calibrated Parameters**

<table>
<thead>
<tr>
<th>R&amp;D scale</th>
<th>R&amp;D scale</th>
<th>Step size</th>
<th>Iceberg</th>
<th>$F(n)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_A$</td>
<td>$\alpha_B$</td>
<td>$\tilde{\alpha}_A$</td>
<td>$\tilde{\alpha}_B$</td>
<td>$\lambda$</td>
</tr>
<tr>
<td>0.69</td>
<td>1.14</td>
<td>44.6</td>
<td>8.77</td>
<td>1.49%</td>
</tr>
</tbody>
</table>
Patenting Intensity - not smoothed
Generlized CES Production Function

Profit with Generalized CES, $\varepsilon=10$

Validation IV: Technology Gaps and Trade

Data support the model prediction: higher exports in sectors with larger tech lead.
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Validation IV: R&D Elasticity

- Exploit variation in R&D tax credit across states:

<table>
<thead>
<tr>
<th>Dep. Var.:</th>
<th>$\ln (R&amp;D_t)$</th>
<th>$\ln (Patents_t)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln (State\ credit_t)$</td>
<td>3.153 ($10.92$)**</td>
<td>2.948 ($10.93$)**</td>
</tr>
<tr>
<td>Year dummy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Firm dummy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

$$\ln Y_{jst} = const. + \ln SC_{st} + \psi_j + \psi_t + u_t$$

- Model counterpart of R&D elasticity:

$$\frac{d \log (R&D)}{d \log (Subsidy)} \approx 2.30$$
Policy Interaction

Figure: Optimal R&D policies for different tariff levels
Q1. What is the impact of a **20% increase in US tariffs** on **foreign welfare**?
Welfare Effects of Protectionist Policies on Foreign

Q1. What is the impact of a 20% increase in US tariffs on foreign welfare?

It is negative and deteriorates over time.
Welfare Effects of Protectionist Policies: Retaliation

Q1. How does optimal tariff respond when foreign country retaliate?

**Figure**: Optimal joint policy under retaliation
Optimal Joint Policy

- How does optimal tariff respond when foreign country retaliate?

A) Optimal innovation response to tariffs

B) Optimal tariff policy

**Figure:** Innovation response to tariffs and optimal tariff policy
Modeling Labor in the Intermediate Goods Sector

- Assume that intermediate goods are produced using labor:

\[ k_{jt} = \frac{\bar{q}_{ct}}{\eta} l_{jt}. \]

- Profits from domestic sales and exports become

\[
\pi(q_{jt}) = \left[ \frac{1 - \beta}{\eta} \frac{\bar{q}_{ct}}{w_{ct}} \right]^{\frac{1-\beta}{\beta}} \beta q_{jt} \quad \text{and} \quad \pi^*(q_{jt}) = \left[ \frac{1 - \beta}{(1 + \kappa) \eta} \frac{\bar{q}_{ct}}{w_{ct}} \right]^{\frac{1-\beta}{\beta}} \beta L_f q_{cjt}.
\]

- Solving for the wage yields

\[
\frac{w_{ct}}{\bar{q}_{ct}} = \chi \bar{q}_{ct}^{-\beta} \left[ \frac{Q^D_{ct}}{\bar{Q}_{ct}} + \frac{Q^X_{ct}}{\bar{Q}_{ct}} + \left(1 + \kappa\right) \frac{\beta - 1}{\beta} \frac{Q^X_{ct}}{\bar{Q}_{ct}} \right]^{\beta} \equiv \chi \left[ \frac{\bar{Q}_{ct}}{\bar{q}_{ct}} \right]^\beta.
\]

- In the special case where \( \bar{q}_{ct} = \bar{Q}_{ct} \) we have

\[ w_{ct} = \chi \bar{Q}_{ct}. \]
Welfare Effects of Protectionist Policies

1. What is the welfare effect of a 20% increase in tariffs?
2. What is the effect of a 20% increase on innovation?

**Figure:** Welfare effects of protectionism: unilateral 20% increase in trade barriers
Welfare Effects of Protectionist Policies

1. How does innovation respond to an increase in the tariff rate?
2. What is the optimal tariff rate for different policy horizons?
Optimal Subsidy Policy

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

Figure: Optimal U.S. R&D subsidy, over different horizons and levels of openness
Welfare Effects of Protectionist Policies, with $\bar{m} = 10$

Q1. What is the impact of a 20% increase in tariffs on welfare and innovation?

A) Consumption equivalent welfare

B) Innovation response of incumbents
Welfare Effects of Protectionist Policies, with $\bar{m} = 10$

Q1. What is the optimal tariff rate for different policy horizons?
Optimal Subsidy Policy, with $\bar{m} = 10$

Q1. What is the optimal subsidy rate for different policy horizons?


