Intellectual Property, Tariffs, and International Trade Dynamics[1]

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[1]The views in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the Bureau of Economic Analysis, the Federal Reserve Bank of Atlanta, or the Board of Governors of the Federal Reserve System.

Motivation

Donald J. Trump
@realDonaldTrump

We are not in a trade war with China, that war was lost many years ago by the foolish, or incompetent, people who represented the U.S. Now we have a Trade Deficit of $500 Billion a year, with Intellectual Property Theft of another $300 Billion. We cannot let this continue!

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1. Are trade and intellectual property transfer related? If so, how?
2. How does trade policy interact with IP protection?
3. How is welfare impacted by changes in these policies?

This Project

- **Uses evidence of technology diffusion through supply chains**
- **Adds Technology Capital** (e.g. patents, brands, blueprints) **to a workhorse dynamic trade model**
  1. Non-Rival Technology Capital is licensed to both domestic and foreign good producers in exchange for royalty fees
  2. Appropriated if not protected
  3. Two Policy Levers: **Tariffs and Enforcement of Intellectual Property Rights (IPR)**

Trade offs

U.S. Trade-offs

Technology Capital is Non Rival: More royalties when licensed to more countries

1. Licensing IP may expose it to appropriation overseas
2. Licensed firms in both countries may be displaced by counterfeiters
3. Returns to technology capital depend on both the extent of appropriation and the number of locations using it

China Trade-offs

Appropriate U.S. Technology Capital

1. Appropriated technology capital can be used without paying a fee
2. Lose access to U.S. markets, as counterfeit goods cannot be exported
3. Deter future transfers of U.S. technology

Preview of Results

U.S. Tariffs lower bilateral trade and output in both countries
But increase U.S. Consumption/Welfare

- Tariffs are rebated to consumers and the exchange rate appreciates
- China substitutes for U.S. imports with domestic production which uses U.S. technology and therefore pay more royalties

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If China retaliates, sparking a "tariff war," punishes only itself

- Much less productive than U.S., so it is very costly to replace U.S. imports if trade collapses.

Alternative Ways to Retaliate

Effective Retaliation: Relax the protection of U.S. IP

- Counterfeiters displace licensed Chinese firms: lower royalties for U.S. technology producers
- U.S. exporters suffer as counterfeiters replicate imported goods
- Output and consumption increase in China, both fall in the U.S.

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Implications:

- U.S. **can punish China with Tariffs**

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Cooperation between countries results in higher welfare

Model

Home (U.S.): Two Households

Technology Capital Entrepreneurs:

- Produce technology capital and earn royalties/licensing fees from licensed (Melitz) firms in U.S. and China
- **Decision:** Invest in technology capital for tomorrow & chose the quantity to be transferred overseas, but risk it being appropriated

Workers/Firm owners

- Work in firms and earn wages
- **Decision:** Consume or buy equities in a mutual fund of firms
- Equity Markets fund the entry of new firms
- New (Melitz) firms need to license (buy) the technology capital to start operating

Foreign (China): One household owns two firms

Licensed Firms

- Behave identically to U.S. goods-producing Melitz-type firms
- Start-ups pay royalties to U.S. entrepreneurs for the technology capital

Appropriating Firms (counterfeiters)

- Appropriate technology capital to produce
- Are less productive and/or their goods are less valuable to consumers
- Output cannot be exported to U.S.

Joint ownership (Yuandan goods):

- When renting U.S. technology for their licensed firms, households internalize gains from future appropriation.

Model Basics: Technology Capital Accumulation.

Home entrepreneurs invest X_t in new technology capital The stock, M_t, evolves:

$$M_t = X_t + (1 - \delta_M) M_{t-1}$$

Non-Rival good: *Same* X_t serves to accumulate technology abroad (M_t^*). But entrepreneurs choose to rent only a fraction $q_t \in (0, 1)$ abroad. For every share q_t rented, appropriators will appropriate $h(q_t)$.

Stock of licensed capital deployed in Foreign:

$$M_t^* = X_t + (1 - \delta_M) \ (1 - h(q_t)) M_{t-1}^*$$

Stock appropriated by Counterfeiters:

$$M_{\mathbf{c},t}^* = h(q_t) M_{t-1}^* + (1 - \delta_M^*) M_{\mathbf{c},t-1}^*$$

Home

Technology Capital Entrepreneurs

Entrepreneurs choose consumption ($C_{e,t}$), investment (X_t) to produce non-rival know-how (M_t), and how much tech capital to deploy, q_t. They earn royalties by renting it to foreign (R_t^*) and home licensed firms (R_t). They maximize utility subject to:

$$\begin{aligned} M_t &= X_t + (1-\delta_M)M_{t-1} \\ M_t^* &= X_t + (1-\delta_M)(1-h(q_t))M_{t-1}^* \end{aligned}$$

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$h(q_t)$ will be an exogenous policy variable

Licensed firms pay fixed cost $f_{E,t} = R_t M_{t-1}$ to enter

Key Equilibrium Conditions: Entrepreneur

$$C_{e,t}^{-\gamma} = \lambda_t + \lambda_t^*$$

$$\lambda_t = \beta \mathbb{E}_t \left\{ C_{e,t+1}^{-\gamma} \left(R_{t+1} N_{E,t+1} \right) + \lambda_{t+1} \left(1 - \delta_M \right) \right\}$$

$$\lambda_t^* = \beta \mathbb{E}_t \left\{ C_{e,t+1}^{-\gamma} \left(\mathbb{Q}_{t+1} q_{t+1} R_{t+1}^* N_{E,t+1}^* \right) + \lambda_{t+1}^* (1 - \delta_M)(1 - h(q_{t+1})) \right\}$$

- λ_t and λ_t^*: multipliers on the LOM for technology capital
- Entrepreneurs face trade-off between
  - Earning royalties from renting their technology capital abroad
  - Experiencing faster depreciation as a result of appropriation abroad

Licensed Firms

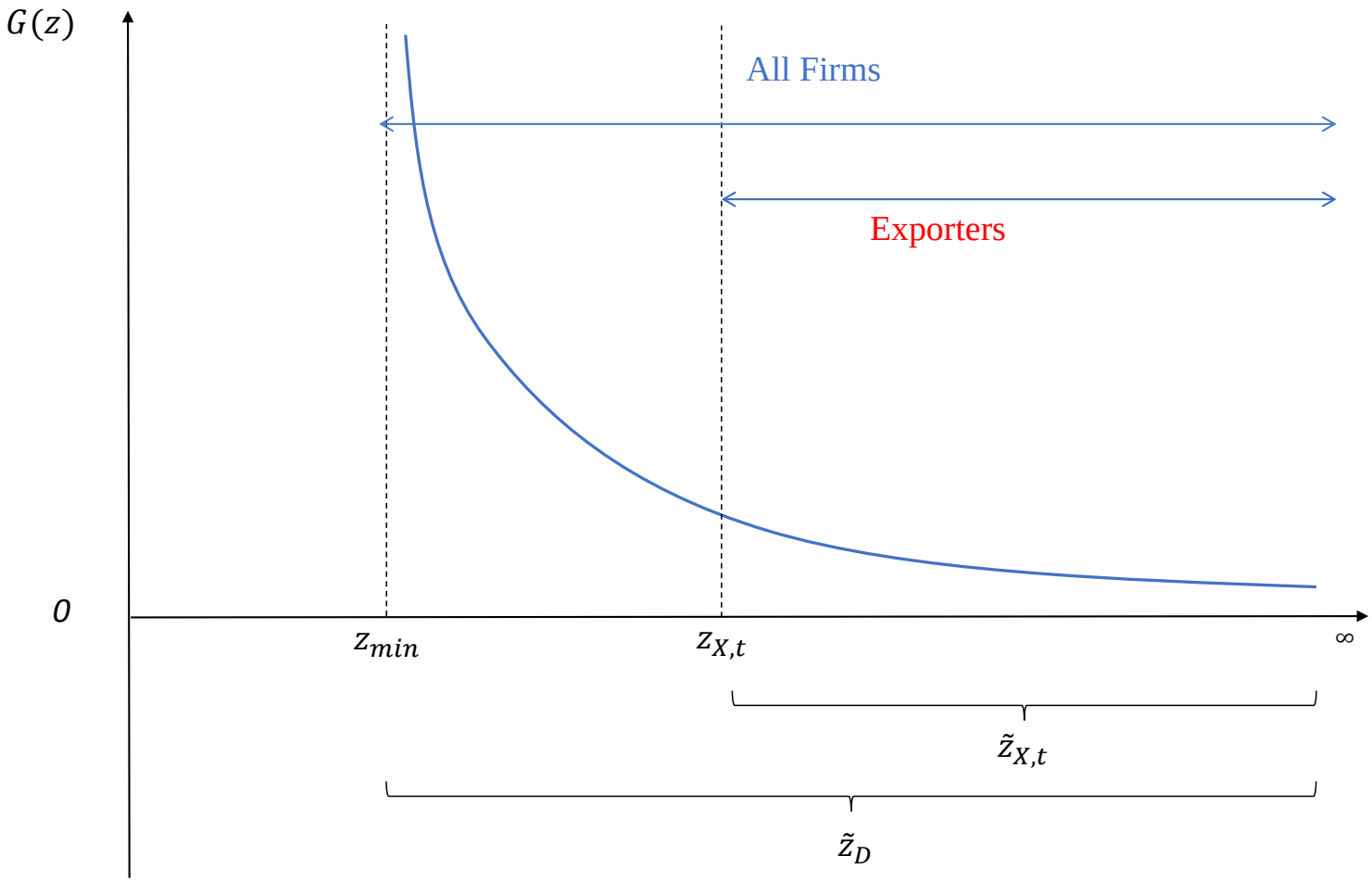
Heterogeneous firms

- Pay sunk entry cost: Prospective new firms pay lump-sum royalties, $f_{E,t} = R_t M_{t-1}$, for the use of *know-how* to start operating.
- Upon entry, they draw idiosyncratic productivity, $\mathbf{z}$, from a Pareto Distribution $G(\mathbf{z}) \sim [\mathbf{z}_{\min}, \infty)$
  - Exogenously exit in any period with probability δ
  - Most productive firms (high $\mathbf{z}$) export
- Monopolistic competitors produce differentiated varieties $\omega \in \Omega$.
- Output of the variety produced using only labor – each firm produces $Z_t \mathbf{z}$ units of output per unit of labor employed
- Home and Foreign varieties $\{\omega\}$ combined into CES consumption

$$C_t = \left(\int_{\omega \in \Omega} c_t(\omega)^{(\theta-1)/\theta} d\omega \right)^{\theta/(\theta-1)}$$

Timing

Distribution of Firms



Foreign

Foreign Firms

Licensed Firms behave identically to U.S. Firms

- Pay fixed cost $f_{E,t} = R_t^* M_{t-1}^*$ to enter

Appropriating Firms use appropriated capital ($M_{\mathbf{c},t}$) and labor ($\bar{L}_c$)

$$Y_{\mathbf{c},t} = Z_t^* \left(\Psi \tilde{\mathbf{z}}_{\mathbf{D}}^*\right) \left(M_{\mathbf{c},t-1}\right)^{\alpha} \left(\bar{L}_c\right)^{1-\alpha}$$

- Z_t^*: country-level TFP
- $\tilde{\mathbf{z}}_{\mathbf{D}}^*$: average productivity of Foreign Licensed firms
- $\Psi \in (0,1)$: productivity loss when using appropriated tech capital

Foreign Households

- Consume goods from licensed producers, C_t^* and counterfeiters $C_{\mathbf{c},t}^*$
- Aggregate Consumption: $C_{\mathbf{a},t}^* = C_t^* + C_{\mathbf{c},t}^*$, where $C_{\mathbf{c},t}^* = Y_{\mathbf{c},t}^*$
- Supply labor inelastically to both firms $(\bar{L}^*, \bar{L}_c^*)$
- Maximize $U(C_{\mathbf{a},t}^*)$ subject to:

$$N_{E,t}^* \tilde{v}_t + C_{\mathbf{a},t}^* = \underbrace{w_t^* \bar{L}^* + N_{D,t}^* \tilde{d}_t^*}_{\text{Income from Licensed Firms}} + \underbrace{w_{\mathbf{c},t}^* \bar{L}_{\mathbf{c}}^* + R_{\mathbf{c},t} M_{\mathbf{c},t-1}}_{\text{Income from Counterfeiting}} + \underbrace{\Pi_{h,t}}_{\text{Tariffs}},$$

Policy

Exogenous Policy Variables

Two policy levers:

- Foreign appropriation of Home Technology Capital

$$h(q_t) = \varepsilon_t^q \left(\varepsilon_t^{\tau^*}\right)^{\phi^*} f(q_t)$$

- Home tariffs on Foreign Imports:

$$\tau_t^* = \varepsilon_t^{\tau^*} \left(\varepsilon_t^q\right)^{\phi} \tau^*$$

Appropriation Policy

Foreign appropriation of Home Technology Capital

$$h(q_t) = \varepsilon_t^q \qquad\qquad f(q_t)$$

- $f(q_t)$ increasing & convex – functional form from HMP (2015)

$$f(q_t) = [q_t \exp(-\eta(1 - q_t))]$$

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  - Convex: Less willing to transfer best technology ("crown jewels")

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- ε_t^q: exogenous innovation to enforcement of IPR in Foreign
- $\varepsilon_t^{\tau^*}$: exogenous innovations to U.S. tariffs
- If $\phi^* > 0$, China responds to increase in U.S. tariffs with more appropriation

U.S. Tariff Policy

Home tariffs on Foreign Imports:

$$\tau_t^* = \varepsilon_t^{\tau^*} \qquad \tau^*$$

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- If $\phi > 0$, U.S. responds to increase in Chinese appropriation with higher tariffs

Experiments & Results

Model Scenarios

1. Exogenous increase in tariffs on Chinese imports to U.S.
2. Retaliation to tariffs with increased appropriation
3. If we have time
   - Tit-for-tat trade war with escalating tariffs
   - Retaliation to appropriation with tariffs

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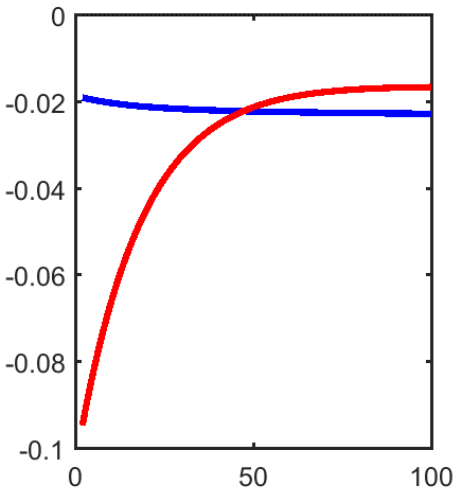
Blue lines will be U.S. and Red lines will be China

Model Scenario 1

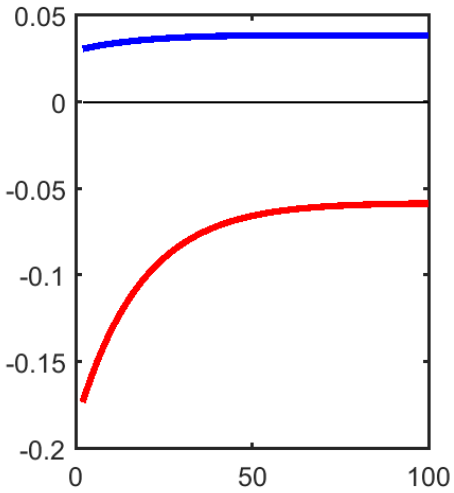
Exogenous unilateral 1% increase in tariffs on Chinese imports to U.S.

- No policy interaction ($\phi, \phi^* = 0$)
- Immediate implementation

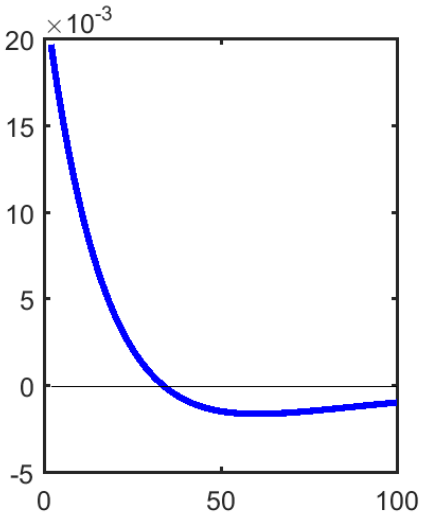
Scenario 1: Unilateral Tariff Increase - Immediate



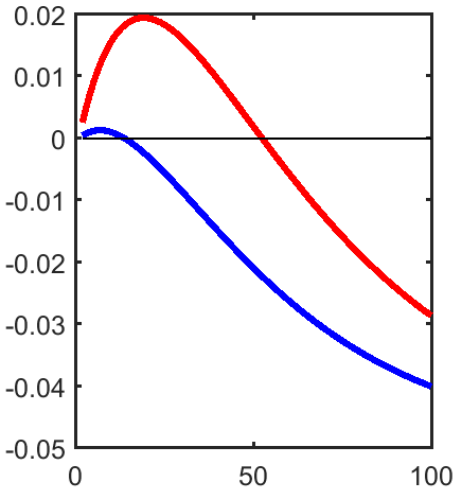
Output



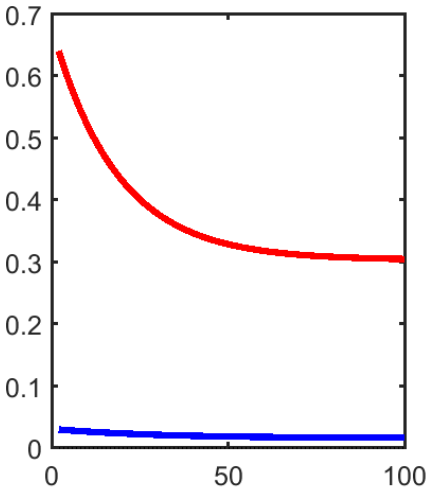
Aggregate Consumption



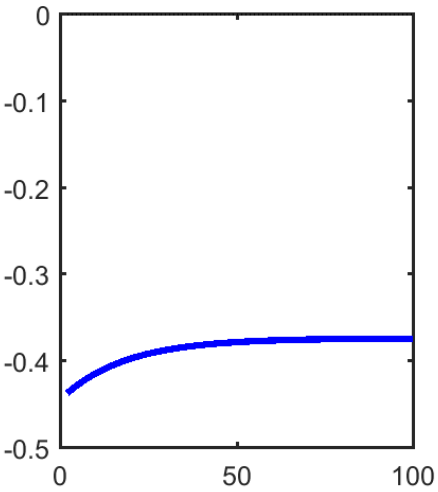
Transfer rate choice (q)



Stock Home IT and Foreign Appropriated



Home firm creation



Real Exchange Rate (CPI based)

Scenario 1: Results

As tariffs increase

- Standard results
  - Imports to U.S. fall, balanced trade implies exports fall too
  - Output falls
- Consumption in Home rises
  - Tariffs are rebated to households & entrepreneurs in lump-sum
  - RER appreciation in Home
  - Less trade means more domestic varieties consumed – more firm creation in both countries
  - Entrepreneurs receive more royalties from this firm creation, so their consumption increases
- Investment in technology capital decreases over time
  - Drop in exports lowers expected profits from firm entry
  - Return to M falls, as do royalty rates on M

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Tariffs boost Home consumption, but deter innovation

Entrepreneur Response

Model Scenario 2

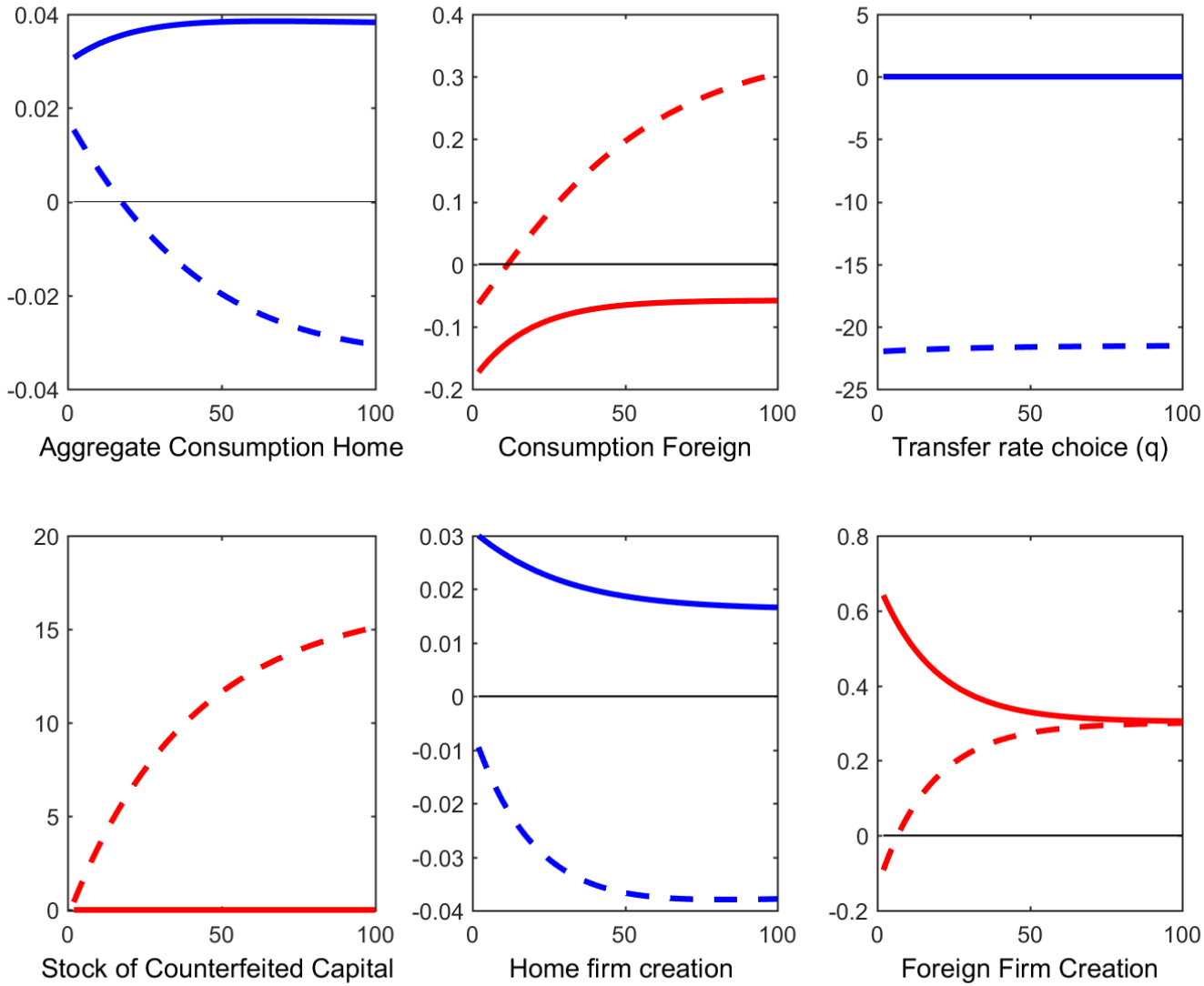
Retaliation to Tariffs with Increased Appropriation

$$h(q_t) = \varepsilon_t^q \left(\varepsilon_t^{\tau^*}\right)^{\phi^*} f(q_t)$$

- Shock tariffs on U.S. imports of Chinese goods ($\varepsilon_t^{\tau^*} \uparrow$ exogenously)
- Allow endogenous response by China ($\phi^* \neq 0$)
- $f(q_t) = [q_t \exp(-\eta(1 - q_t))]$ as in HMP (2015)

Scenario 2: Increase in Tariffs with and without Retaliation

Solid: Baseline ($\phi^* = 0$), Dotted: Appropriation retaliation ($\phi^* > 0$)



Scenario 2: Results

With retaliation:

- Increased appropriation moves production from licensed firms
  - Output from Chinese licensed firms replaced by "counterfeit" goods
  - Exports from U.S. replaced by "counterfeit" goods
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- Home firm creation falls
  - Fall in exports from U.S. means expected profits for U.S. firms falls
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Foreign effectively retaliates against Home tariffs by increasing appropriation

Entrepreneur Response Other Scenarios

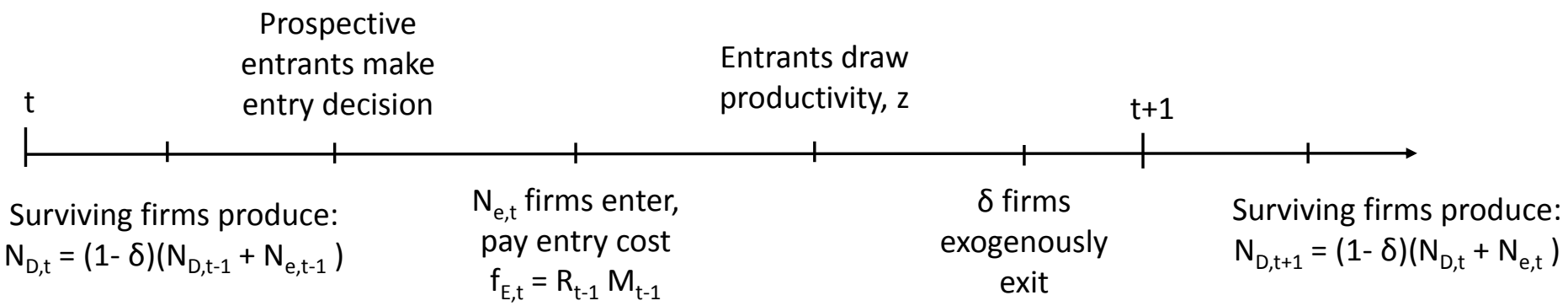
Conclusions

Key Findings:

- Both tariffs and IPR enforcement policies impact the development and diffusion of technology capital
- Tariffs are bad for innovation, even when appropriation of technology capital is possible
- Increases in foreign tariffs are not effective deterrent to increase in Home tariffs, but decreased protection for IPR is
- Increasing home tariffs may be an effective deterrent for bad IPR protection in Foreign
- Each country has an effective tool for retaliation, so there may be scope for cooperation

Thank you!

Timing



Back to Licensed Firm Details

Entrepreneur Response to Scenario 1

$$C_{e,t} + X_t = R_t M_{t-1} N_{E,t} + \mathbb{Q}_t R_t^* (q_t M_{t-1}^*) N_{E,t}^* + \Pi_{e,t}$$

$$C_{e,t}^{-\gamma} = \lambda_t + \lambda_t^*$$

$$\lambda_t = \beta \mathbb{E}_t \left\{ C_{e,t+1}^{-\gamma} \left(R_{t+1} N_{E,t+1} \right) + \lambda_{t+1} \left(1 - \delta_M \right) \right\}$$

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- Income rises when firm creation increases: $N_{E,t}, N_{E,t}^* \uparrow$

Entrepreneur Response to Scenario 1

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- Income rises when firm creation increases: $N_{E,t}, N_{E,t}^* \uparrow$
- Return to investing in technology capital falls: $R_t, R_t^* \downarrow$

Entrepreneurs consume more, invest less. Stock of M, M^* falls over time.

Back to Scenario 1

Entrepreneur Response to Scenario 2

$$C_{e,t} + X_t = R_t M_{t-1} N_{E,t} + \mathbb{Q}_t R^*_t (q_t M^*_{t-1}) N^*_{E,t} + \Pi_{e,t}$$

$$C^{-\gamma}_{e,t} = \lambda_t + \lambda^*_t$$

$$\lambda_t = \beta \mathbb{E}_t \left\{ C^{-\gamma}_{e,t+1} \left(R_{t+1} N_{E,t+1} \right) + \lambda_{t+1} \left(1 - \delta_M \right) \right\}$$

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- Income falls when firm creation falls: $N_{E,t}, N^*_{E,t} \downarrow$

Entrepreneur Response to Scenario 2

$$C_{e,t} + X_t = R_t M_{t-1} N_{E,t} + \mathbb{Q}_t R_t^* (q_t M_{t-1}^*) N_{E,t}^* + \Pi_{e,t}$$

$$C_{e,t}^{-\gamma} = \lambda_t + \lambda_t^*$$

$$\lambda_t = \beta \mathbb{E}_t \left\{ C_{e,t+1}^{-\gamma} \left(R_{t+1} N_{E,t+1} \right) + \lambda_{t+1} \left(1 - \delta_M \right) \right\}$$

$$\lambda_t^* = \beta \mathbb{E}_t \left\{ C_{e,t+1}^{-\gamma} \left(\mathbb{Q}_{t+1} q_{t+1} R_{t+1}^* N_{E,t+1}^* \right) + \lambda_{t+1}^* (1 - \delta_M)(1 - h(q_{t+}$$

- Income falls when firm creation falls: $N_{E,t}, N_{E,t}^* \downarrow$
- Return to investing in technology capital falls as more technology is appropriated: $R_t, R_t^* \downarrow$

Entrepreneurs consume less, invest less. Stock of M falls, M^* rises through appropriation

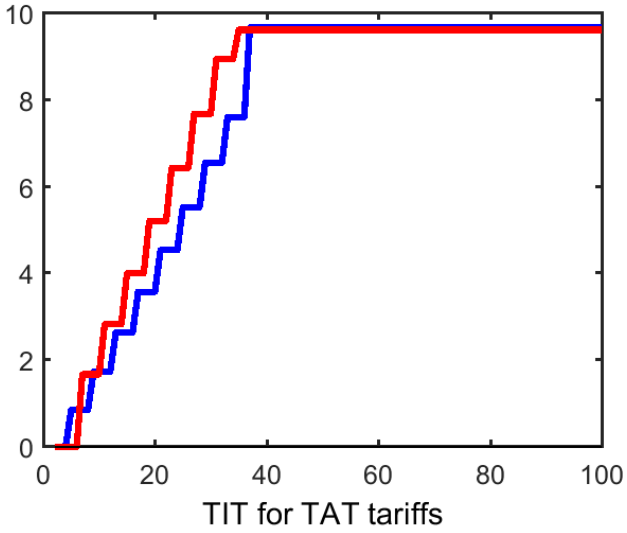
Back to Scenario 2

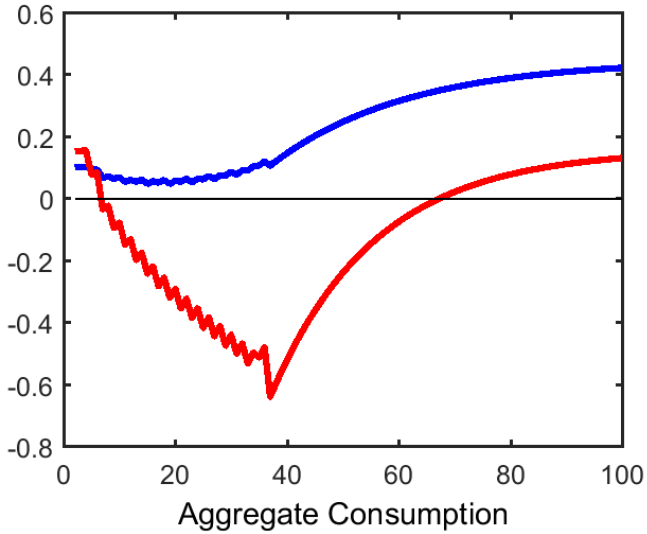
Model Scenario 3

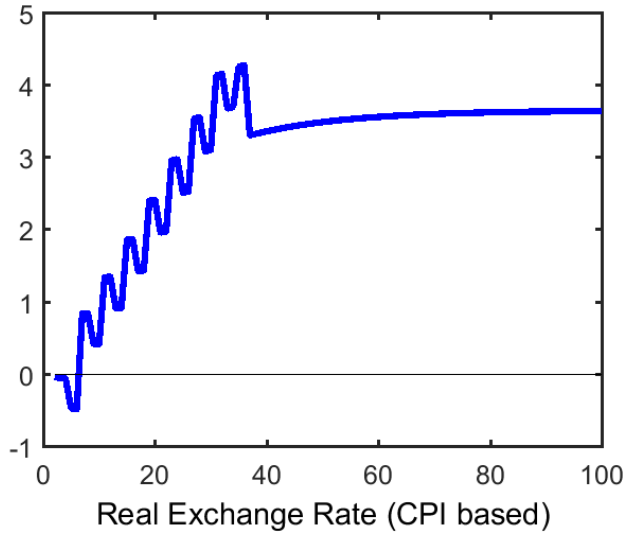
Tit-for-tat trade war ending at 10% increase in tariffs

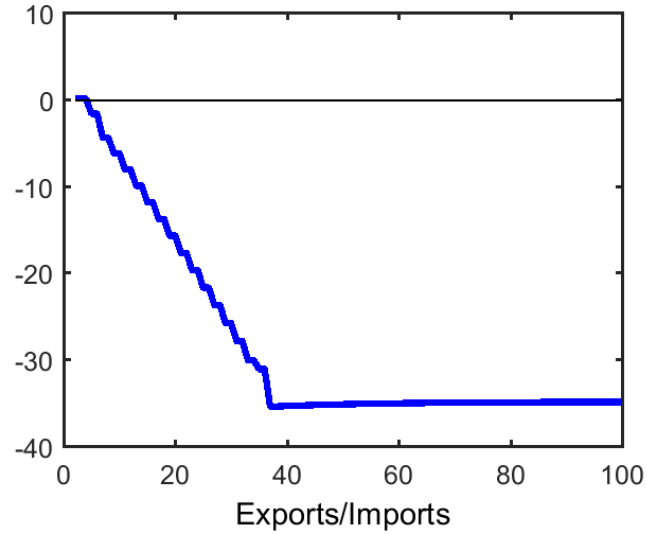
- Baseline tariffs: U.S. 2.9%, China 5.9%
- U.S. increases tariffs on China by 1%
- China retaliates with tariffs on U.S. goods (1% increase)
- Continues until reach 10% increase each

Scenario 3: Tit-for-Tat Trade War









Scenario 3: Results

- Massive reduction in trade
- Foreign output and consumption fall dramatically
  - Foreign tariffs begin at a higher level so increase by much more
  - Increase in tariffs blocks Foreign households from consuming goods from most productive U.S. firms
  - Foreign consumers substitute towards domestic goods which are produced by much less productive firms
- If Home raises tariffs, Foreign only hurts itself through retaliation using tariffs

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Tariffs are not a good retaliatory tool for Foreign

Model Scenario 4

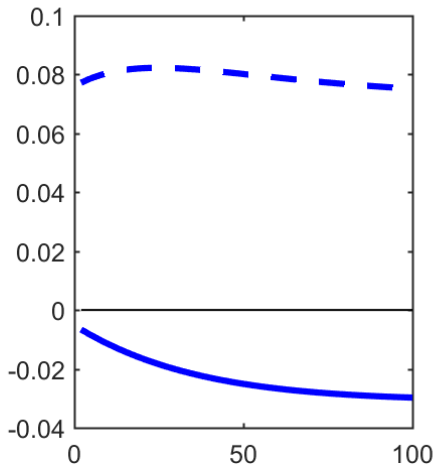
Retaliation to Appropriation with Tariffs

$$\tau_t^* = \varepsilon_t^{\tau^*} \left(\varepsilon_t^q\right)^{\phi} \tau^*$$

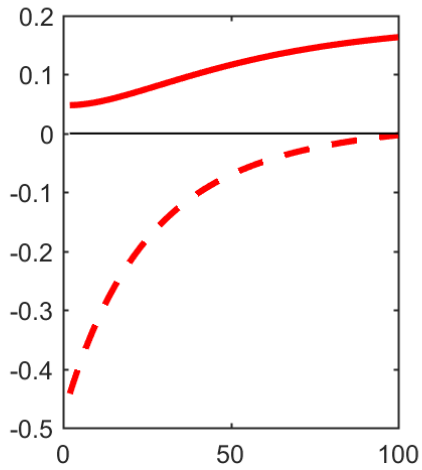
- Shock Chinese appropriation of U.S. technology capital ($\varepsilon_t^q \uparrow$)
- Allow endogenous response by U.S. ($\phi > 0$)

Scenario 4: Appropriation with and without Retaliation

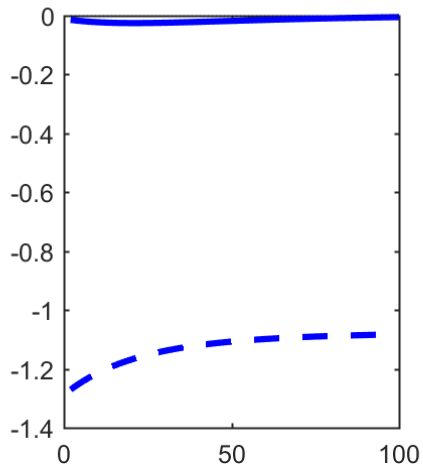
Solid: No retaliation ($\phi = 0$), Dotted: Tariff retaliation ($\phi > 0$)



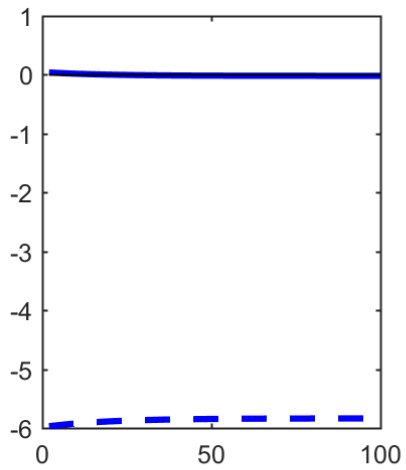
Aggregate Consumption Home



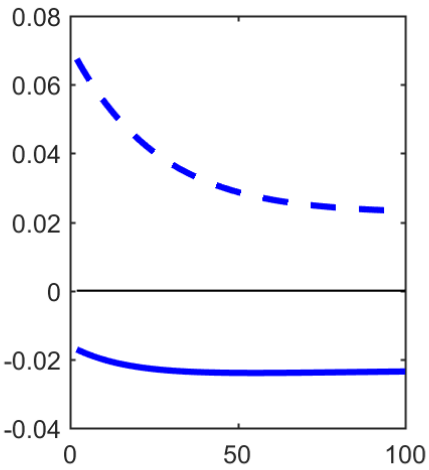
Consumption Foreign



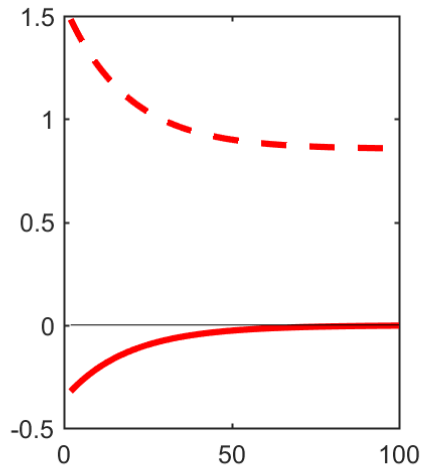
Real Exchange Rate (CPI based)



Exports/Imports



Home Firm creation



Foreign Firm Creation

Scenario 4: Results

Increase in appropriation rate ($\varepsilon_t^q \uparrow$):

- Without retaliation, looks like previous scenario
  - Appropriation increases dramatically
  - Foreign consumption increases at cost of Home consumption
- With retaliation
  - Imports to & exports from Home decrease
    - Households in both countries consume more domestic goods
    - Firm creation increases to supply these goods
    - Royalty receipts for entrepreneurs increase
  - U.S. consumption increases due to
    - Income from lump-sum transfers
    - RER appreciation
    - Entrepreneurs increase in royalty receipts due firm creation

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Retaliatory tariffs can revert the benefits from increased appropriation to loses for Foreign

Back to Conclusions