Trade Liberalization and Firm Dynamics

Ariel Burstein and Marc Melitz
What We Do & Motivation

- Analyze how firm dynamics and endogenous innovation give rise to aggregate transition dynamics (consumption, trade volumes, productivity) in response to trade liberalization

- Firm and aggregate dynamics are shaped by the following elements:
  - Firm heterogeneity in both innovation and export decision
  - Endogenous entry and exit
  - Forward looking feedback loop between all those decisions
  - Anticipation effects regarding trade policy

Why is this important? Because...

1. Firm level dynamics generate very different paths for important aggregate variables
2. Steady state outcome can give a misleading picture of overall response: Long lasting dynamic adjustments lead to very different NPV measures
3. Firm-level dynamics are interesting per-se: How key model "ingredients" interact to induce different firm responses over time
4. Anticipation effects are especially important w.r.t. trade policy
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Broad Research Agenda

Consistent evidence from recent empirical work on producer-level responses to globalization:

- Changes in aggregate trading environment impact the decisions of heterogeneous firms (or plants) to
  - Export (and choice of export locations)
  - Enter and exit
  - Innovate and invest in R&D
  - Adapt technology and mode of operation
    - International supply chain
    - Horizontal & vertical FDI
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    - Horizontal & vertical FDI
- Motivates the design of models explaining the heterogeneous response of firms to trade liberalizations
  - Capture the important composition effects for aggregate variables (trade flows, investment, ..., and ultimately welfare)
  - ... and endogenous source of comparative advantage
Firm Dynamics Are Relevant for this Research Agenda

A substantial portion of the theoretical literature in this area assumes:

- No firm dynamics (life cycle or idiosyncratic uncertainty)
- Stable aggregate environment

- Implies producers’ choices regarding international market participation and technology do not change over time
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- In this paper, we focus on these dynamic interactions
Focus on models that build on GE literature of firm productivity dynamics and add firm-level decisions regarding international market participation (typically an export decision)

Specifically examine the predictions for the dynamic responses to trade liberalization involving the following firm decisions:

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Analyze how firm dynamics and endogenous innovation give rise to aggregate transition dynamics (consumption, trade volumes, productivity) in response to trade liberalization

- How does timing of trade liberalization matter?
  - Permanent versus temporary
  - Unanticipated versus anticipated
What We Do (Cont.)

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- Specifically examine the predictions for the dynamic responses to trade liberalization involving the following firm decisions: Entry/exit, export, and innovation
- Analyze how firm dynamics and endogenous innovation give rise to aggregate transition dynamics (consumption, trade volumes, productivity) in response to trade liberalization
  - How does timing of trade liberalization matter?
    - Permanent versus temporary
    - Unanticipated versus anticipated
- We develop theoretical and computational models of firm dynamics, innovation, and international trade to answer these questions
Brief Survey of Related Theory

- Aggregate models of firm dynamics

- Firm dynamics and international trade

- Models of innovation by incumbent firms

- Static models of innovation by incumbents and international trade

- Models of innovation, firm dynamics and international trade
Key Results

- When is a sudden permanent change in trade costs likely to induce endogenous adjustment dynamics for key aggregate outcomes?
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- We highlight this important interaction by developing two analytical benchmark models that do not feature any endogenous dynamics:
  1. No export market selection
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  1. No export market selection
  2. Endogenous export market selection but no firm dynamics (even with endogenous innovation)
- Size of entrants and their likelihood of exporting (both relative to incumbents) key in shaping response of entry and transition dynamics
Key Results (Cont.)

- Endogenous innovation amplifies differences in productivity between exporters and non-exporters.
- Transition dynamics take long time to unfold, implies higher elasticity of trade volumes relative to output in long run than in short run.

Note: The results regarding cumulative welfare gains from Atkeson & Burstein (2009) still hold.
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Brief Survey of Empirical Work Highlighting These Interactions

- **Hysteresis effects:**

- **Response of productivity/innovation to trade liberalization**
  - Lileeva & Trefler (2009) for Canada; Verhoogen (2009) for Mexico; and Bustos (2010) for Argentina; Aw, Roberts & Xu (2010) for Taiwan; Bloom et al. (2009) for competition from Chinese imports

- **Market demand dynamics**
  - Eaton et al. (2010)

- **Anticipation effects ahead of changes in trade costs**
  - Das et al. (2007): Effects of anticipated changes in exchange rates in some sectors
  - Bergin & Lin (2010): Entry into export markets ahead of EMU
  - Vanbeveren & Vandenbussche (2010): Increased firm innovation ahead of entry into new export markets
Model
Model Overview

- 2 country symmetric model (no terms of trade or current account dynamics)
- Common CES product differentiation across all products (in both countries)
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- Heterogeneous firms stemming from firm-specific factor $z$ (productivity, loosely defined)
  - Entry subject to sunk cost
  - Firm productivity $z$ then evolves stochastically
  - Firms can influence this evolution process via innovation

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Preferences

- Consumption index $C_t$ is CES aggregate of all available varieties (domestic and imported)
  - Symmetric elasticity of substitution $\rho > 1$
  - In equilibrium, this is also the value of aggregate production $Y_t$
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  - In equilibrium, this is also the value of aggregate production $Y_t$
  - Let $P_t$ denote the CES price index of consumption
- Inter-temporal preferences of representative household given by:

$$U = \sum_{t=0}^{\infty} \beta^t \log(C_t)$$

where $\beta \in (0, 1)$ is standard discount factor

- Equilibrium interest rate is determined by these intertemporal preferences:

$$R_t = \frac{1}{\beta} \frac{C_{t+1}}{C_t}$$

(no aggregate uncertainty so perfect foresight)
Production and Trade

- Labor is only factor of production (and numeraire)
- Each firm produces a separate differentiated variety
- Firm hires $l_t(z)$ production workers (in addition to overhead labor $f$) and produces output:

$$y_t(z) = \exp(z)^{1/(\rho-1)} l_t(z).$$

so productivity $z$ indexes log differences in firm size (in equilibrium)

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- Increasing returns to scale driven by fixed costs
- A firm chooses to export to symmetric market subject to trade costs:
  - Per-unit “iceberg” cost $\tau > 1$
  - Per-period fixed cost $f_X$
  - Later on, will also add a sunk cost $f_{EX}$
Monopolistic competition: firms sets price in domestic market at constant markup over marginal cost:

\[ p_t(z) = \frac{\rho}{\rho - 1} \frac{1}{\exp(z)^{1/(\rho-1)}} \]
Static profits

- Monopolistic competition: firms sets price in domestic market at constant markup over marginal cost:

\[ p_t(z) = \frac{\rho}{\rho - 1} \frac{1}{\exp(z)^{1/(\rho-1)}} \]

- Define the market demand index:

\[ \Pi_{dt} \equiv \frac{P_t^\rho Y_t}{\rho^\rho (\rho - 1)^{1-\rho}} \]

- Then a firms total profits are given by:

\[ \Pi_t(z) = \Pi_{dt} \exp(z) - f + x_t(z) \left[ \Pi_{dt} \tau^{1-\rho} \exp(z) - f_X \right] \]

where \( x_t(z) \in \{0, 1\} \) represents an indicator variable for firm \( z \)'s export status
Productivity dynamics

- Exogenous exit with probability $\delta$ (independent of firm productivity $z$)
- Productivity evolution:
  - Conditional on survival, productivity $z$ can go up or down by an exogenous amount $\Delta z$
    - It increases to $z + \Delta z$ with probability $q$
    - It decreases to $z - \Delta z$ with probability $1 - q$
  - No productivity dynamics: $\Delta z = 0$
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- If time period small, then binomial process approximates geometric Brownian motion in continuous time (as in Luttmer 2006)
Innovation

- Firms can affect this productivity evolution process via innovation, which affects the probability $q$
- The investment cost of a given probability $q$ is $\exp(z) c(q)$ (in units of labor)
  - where $c(q)$ ($c_q > 0$, $c_{qq} > 0$) is the innovation cost function common across firms

For a given $q$, the investment cost is proportional to a firm's size in its domestic market. This implies size-independent growth for large firms, consistent with Gibrat's law.
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  - Same innovation decision by large firms: $\bar{q}_t = \lim_{z \to \infty} q_t(z)$.
Innovation Choice

A firm chooses its innovation level (indexed by the probability \( q \)) to maximize its continuation value:

\[
V^o_t(z) = \max_{q \in [0,1]} \Pi_t(z) - \exp(z) c(q) + (1 - \delta) \frac{1}{R_t} [qV_{t+1}(z + \Delta z) + (1 - q)V_{t+1}(z - \Delta z)]
\]

which yields an optimal innovation level \( q_t(z) \) determined by the FOC:

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- Exogenous innovation is obtained from very steep innovation cost function such that $q_t(z) = \bar{q}, \forall z, t$
Exit

- The exit decision is determined by the maximization of overall firm value:

\[
V_t(z) = \max [0, V_t^o(z)]
\]

which implies an exit cutoff \( \bar{z}_t \) such that \( V_t(\bar{z}_t) = 0 \)
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Entry

- Firms pay sunk investment cost \( f_E \) to enter (in units of labor)
  - ... then draw their initial \( z \) from a common distribution \( G(z) \)
    (potentially degenerate)
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Entry
- Firms pay sunk investment cost \( f_E \) to enter (in units of labor)
  - ... then draw their initial \( z \) from a common distribution \( G(z) \) (potentially degenerate)
- No other restrictions to entry, thus free-entry condition:

\[ \frac{1}{R_t} \int V_{t+1}(z) G(z) \, dz \leq f_E \]

with equality if entry is strictly positive
Aggregation

- CES price index:

\[ P_t = \left[ \int p_t(z)^{1-\rho} M_t(z) \, dz + \int x_t^*(z) [\tau p_t^*(z)]^{1-\rho} M_t^*(z) \, dz \right]^{1/(1-\rho)} \]

where \( M_t(z) \) is measure of operating firms with productivity index \( z \)

- Evolution of \( M_t(z) \) over time is implied by \( q_t(z) \), \( \delta \), and \( \bar{z}_t \), and the mass of entrants \( M_{Et} \):

\[ M_{t+1}(z') = \begin{cases} 
M_{Et} G(z') + (1 - \delta) q_t(z' - \Delta z) M_t(z' - \Delta z) + (1 - \delta) \left[1 - q_t(z' + \Delta z)\right] M_t(z' + \Delta z) & \text{if } z' \geq \bar{z}_{t+1}' \\
0 & \text{if } z' < \bar{z}_{t+1}' 
\end{cases} \]
Labor Market Aggregation

Exogenous aggregate labor supply (normalized to 1) is used for production ($L_{pt}$), innovation ($L_{It}$), and to cover the fixed costs for entry, export, and overhead production (we assume no sunk export costs for now):

$$L_{pt} + L_{It} + M_{Et} f_E + \int [f + x_t(z) f_X] M_t(z) \, dz = 1$$

where

$$L_{pt} = \int l_t(z) M_t(z) \, dz$$

$$L_{It} = \int \left[ \exp(z) c(q_t(z)) \right] M_t(z) \, dz$$
Other Useful Aggregates (Reported in Computations)

- Domestic share of exporters:
  \[
  \frac{\int x_t(z) \exp(z) M_t(z) \, dz}{\int \exp(z) M_t(z) \, dz}
  \]

- Export to GDP (\(Y_t\)):
  \[
  \tau^{1-\rho} \frac{\int x_t(z) \exp(z) M_t(z) \, dz}{\int \exp(z) M_t(z) \, dz + \tau^{1-\rho} \int x_t(z) \exp(z) M_t(z) \, dz}
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  \]

- Average firm productivity:
  \[
  \bar{Z}_t = \frac{\int \exp(z) M_t(z) \, dz}{\int M_t(z) \, dz}
  \]

  - This is proportional to the average firm size on the domestic market at any given level of market demand \(\Pi_{dt}\)
  
  - In other words, \(\bar{Z}_t / \Pi_{dt}\) is equal to average firm size (on the domestic market) in every period \(t\) (up to a normalization constant)
Parameterization: Innovation Cost Function

\[ c(q) = h \exp(bq) \]

- \( b = \frac{c''(q)}{c'(q)} > 0 \) indexes curvature of innovation cost function
- For exogenous innovation case, we pick high enough \( b \) that all firms choose same innovation level \( q_t(z) = \bar{q} \)
Parameterization: Remaining Calibration

- For all cases with productivity dynamics, we use degenerate distribution for entrants at $z = 1$
- We calibrate $(h, f_X, \Delta_z, \tau^{1-\rho}, \delta)$ to US data on (See Atkeson & Burstein 2010 for details):
  - Firm employment-based size distribution.
  - Variance of growth of large firms.
  - Death of large firms.
  - Exports / Gross Output.
  - Share of employment in exporting firms
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Other parameters, do not affect calibration targets: $\rho = 5, f, f_E$
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With Sunk Export Costs:
- Firms must pay additional sunk export cost $f_{EX}$ to become exporters
  - Lose this investment if stop exporting
- We assume that the majority of the fixed export costs are sunk, and calibrate $f_{EX}$ to match the US data above
Trade Liberalization Scenarios

- We consider the effects of a 3.5% reduction in international per-unit trade costs $\tau$
- We use this benchmark trade cost reduction throughout all scenarios
- We first consider the effects of a permanent unanticipated reduction
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- We use this benchmark trade cost reduction throughout all scenarios
- We first consider the effects of a permanent unanticipated reduction
- We then contrast this to:
  - A temporary unanticipated reduction
  - An anticipated (2 years prior) reduction (thereafter permanent)
  - Similar anticipated reduction adding sunk export costs
Results
No Export Market Selection

- No fixed export cost \( f_x = 0 \)
- With/without productivity dynamics (exogenous and endogenous innovation)

Analytic results:
Entry, exit, and innovation do not respond to changes in trade costs.

Offsetting effects of increased export opportunities and reductions in domestic sales from imports, same for all producers.

Hence adjust immediately to new steady state: no transition dynamics.

Steady state consumption gain is limited to direct effect of change in trade cost from \( \tau_0 \) to \( \tau_1 \):

\[
\frac{1}{\rho_1 + \tau_1} - \frac{1}{\rho_1 + \tau_0} = \frac{1}{\rho_1 + \tau_1} - \frac{1}{\rho_1 + \tau_0}
\]

This is identical welfare gain as an Armington model (country produces a single good with exogenous unit labor requirement) and as in Krugman (1980).
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1 + \tau_0 \frac{1}{\rho} + \tau_1 \rho
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Steady state consumption gain is limited to direct effect of change in trade cost from $\tau'$ to $\tau$:

$$\left( \frac{1 + \tau'^{1-\rho}}{1 + \tau^{1-\rho}} \right)^{\frac{1}{\rho-1}}$$

- This is identical welfare gain as an Armington model (country produces a single good with exogenous unit labor requirement) and as in Krugman (1980)
No Export Market Selection (Cont.)

- Illustrate analytic result in following figure
  - Panel A reports $\tau_t / \tau_0$, Panels B-F report $\log (X_t / X_0) / \log (\tau_t / \tau_0)$ for each variable $X$
Permanent liberalization, with or without productivity dynamics, all firms export

Panel A: Trade cost, relative to pre-liberalization

Panel B: Final output (--), Production labor (---)

Panel C: Entry

Panel D: Average firm productivity

Panel E: Export/output (--), Domestic share of exporters (---)

Panel F: Process innovation intensity
No Export Market Selection: Summary

- No change in average firm productivity
- No transition dynamics
Export Market Selection but No Firm Productivity Dynamics

- No productivity dynamics, $\Delta z = 0$ (and hence no innovation)
- Entering productivity $\exp(z)$ distributed Pareto with parameter $\theta > \rho - 1$
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- Entering productivity $\exp(z)$ distributed Pareto with parameter $\theta > \rho - 1$

Analytic results:

- Number of entrants does not depend on the trade cost in steady state (dynamic model extension of Arkolakis et al 2009)
- If trade costs fall, domestic cutoff rises, export cutoff falls
- Immediate transition to new steady state
Permanent liberalization, no productivity dynamics

**Panel A: Trade cost, relative to pre-liberalization**

**Panel B: Final output (---), Production labor (---)**

**Panel C: Entry**

**Panel D: Average firm productivity**

**Panel E: Export/output (--), Domestic share of exporters (---)**

**Panel F: Process innovation intensity**
Export Market Selection but No Firm Productivity Dynamics: Summary

- Bigger trade elasticity due to changes in cutoffs
- Rise in average firm productivity due to reallocation of production towards more productive producers
- No transition dynamics
Export Market Selection and Firm Productivity Dynamics

- We now show how interaction of firm productivity dynamics and export market selection generates aggregate transition dynamics.
- These transition dynamics are generated by the response of entry to the change in the trade cost.
- In order to gain some intuition for the response of entry, we start with a simplified version of our model.
Response of Entry to Trade Liberalization: Building Intuition

Consider the following simplified version of our model:

- All firms have the same productivity level that is constant over time.
- New entrants are non-exporters, exogenously become exporters when $T + 1$ periods old (and remain exporters thereafter).
Response of Entry to Trade Liberalization: Building Intuition

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- All firms have the same productivity level that is constant over time.
- New entrants are non-exporters, exogenously become exporters when $T + 1$ periods old (and remain exporters thereafter).
- Let $s_x$ represent the aggregate share of exports in total sales (in the cross-section).
- Let $\bar{s}_x$ represent an entrant’s net present value of export sales relative to the net present value of total sales.
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- All firms have the same productivity level that is constant over time.
- New entrants are non-exporters, exogenously become exporters when $T + 1$ periods old (and remain exporters thereafter).
- Let $s_x$ represent the aggregate share of exports in total sales (in the cross-section).
- Let $\tilde{s}_x$ represent an entrant’s net present value of export sales relative to the net present value of total sales.

- If $T = 0$ (all firms export) or $\beta = 1$ (no discounting), then $s_x = \tilde{s}_x$.
- As $T$ increases (it takes longer for an entrant to become an exporter) and $\beta$ decreases (more discounting) then $\tilde{s}_x$ decreases relative to $s_x$:
  - Profits from exporting become a less important component of a firm’s value upon entry.
Response of Entry to Trade Liberalization: Building Intuition

Analytic results:

- When trade costs fall, entry falls (increases) in steady state if and only if $\tilde{s}_x < s_x$ ($\tilde{s}_x > s_x$)
- For a given small change in trade costs, the percentage change in entry is proportional to $\tilde{s}_x - s_x$
Response of Entry to Trade Liberalization: Building Intuition

Analytic results:

- When trade costs fall, entry falls (increases) in steady state if and only if \( \tilde{s}_x < s_x \) (\( \tilde{s}_x > s_x \))
- For a given small change in trade costs, the percentage change in entry is proportional to \( \tilde{s}_x - s_x \)

Intuition:

- When \( \tilde{s}_x < s_x \), trade liberalization makes entry less profitable: Incumbent/exporters firms benefit proportionally more than entrants/non-exporters from lower trade costs
- This analytic results can be generalized to a richer structure of productivity and export participation dynamics (see Atkeson and Burstein 2010)
Export Market Selection and Firm Productivity Dynamics

- This same intuition applies to our full model with productivity dynamics and export market selection.
- Following figure considers a parameterization of the model with exogenous productivity dynamics, in which entrants are less likely to export than incumbent firms (i.e. $\tilde{s}_x < s_x$).
Permanent liberalization, exogenous innovation

Panel A: Trade cost, relative to pre-liberalization

Panel B: Final output (-), Production labor (--)

Panel C: Entry

Panel D: Average firm productivity

Panel E: Export/output (-), Domestic share of exporters (--)

Panel F: Process innovation intensity
Export Market Selection and Firm Productivity Dynamics: Summary

- Entry drops along transition and in new steady state
  - Trade liberalization makes entry less profitable: Incumbent/exporters firms benefit proportionally more than entrants/non-exporters
  - Mass of producing firms steadily decreases to its new steady state
- Consumption overshoots its steady state level because more labor can be used in production, mass of firms falls over time
  - Comparing consumption across steady states understates welfare gains from trade liberalization
Export Market Selection and Firm Productivity Dynamics: Alternative Parametrizations

- Consider an alternative parametrization with no discounting ($\beta = 1$)
  - Wait for entrant to become an exporter is now inconsequential
- This increases the importance of the future expected exporting profits for an entrant
  - Entry responds less negatively to trade liberalization
  - Less overshooting of consumption
  - Transition dynamics look more similar to no productivity dynamics
Permanent liberalization, exogenous innovation, positive interest rate (-) and zero interest rate (--)
Export Market Selection and Firm Productivity Dynamics

Consequences of Endogenous Innovation

- Following figure considers a parameterization of the model with endogenous innovation
Permanent Liberalization: Endogenous Innovation

Panel A: Trade cost $\tau$, relative to pre-liberalization

Panel B: Final output $Y (-)$, Production labor LP $(-)$

Panel C: Entry, ME

Panel D: Average firm productivity, $Zbar$

Panel E: Export share $sX (-)$, Exporters domestic share $sD (--)$

Panel F: Innovation by large exporters, $q(z)$ high $z$
Export Market Selection and Firm Productivity Dynamics
Consequences of Endogenous Innovation

- Innovation intensity by exporters rises
  - Lower trade costs increase the value of exporters relative to non-exporters, and the former respond by innovating relatively more
  - Average firm productivity increases, driven by the productivity increase of exporters
- Increase in relative size and productivity of exporters takes a long time to unfold

- Trade volumes relative to output steadily increases as exporters become relatively more productive
  - Short run elasticity of trade with respect to trade costs is substantially smaller than the long run elasticity

- Consumption undershoots its steady state level
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- Anticipation effects: Some non-exporters increase innovation in anticipation of future export status
Export Market Selection and Firm Productivity Dynamics: Increased Innovation by Non-Exporters

Change in innovation intensity by firm across steady-states

- Log change in innovation intensity $q(z)$
- Initial export threshold
- New export threshold

z - z exit threshold

0 2 4 6 8 10 12 14 16
Permanence of Trade Liberalization

- For these endogenous changes in productivity and trade volumes (arising from changes in endogenous innovation) to be important, trade liberalization must be perceived to be long lasting.
- The following figure considers a parameterization of the model with endogenous productivity dynamics.
  - Temporary reduction in trade costs (see path of $\tau$ in Panel A).
Permanent (-) and Temporary (--) Liberalization, Endogenous Innovation

Panel A: Trade cost, $\tau$

Panel B: Innovation by large exporters, $q(z)$ high $z$

Panel C: Exporters domestic share, $sD$
Permanence of Trade Liberalization

Two key effects:

1. Incentives: Entry and innovation responses are forward looking
   - Permanence of trade liberalization affects incentives for entry and innovation
   - Innovation intensity by exporters rises by less when reduction in trade costs is temporary

2. Transition dynamics are slow: given incentives, changes in entry and innovation take a long time to unfold
   - As time window for lower trade costs is reduced, the role of endogenous innovation becomes increasingly muted

The following figure shows that the differences between endogenous and exogenous innovation are very muted when trade liberalization is temporary
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   - As time window for lower trade costs is reduced, the role of endogenous innovation becomes increasingly muted
   - The following figure shows that the differences between endogenous and exogenous innovation are very muted when trade liberalization is temporary
Temporary liberalization, exogenous (-) and endogenous (--) innovation

Panel A: Trade cost

Panel F: Innovation intensity by exporters

Panel E: Domestic share of exporters
Anticipation Effects: Response of Endogenous Innovation

- The following figure considers an anticipated, permanent reduction in trade costs (see path of $\tau$ in Panel A) in the parametrizations of the model with exogenous and endogenous innovation.

- Anticipation effects for innovation: rise in innovation precedes reduction in trade costs if the latter is anticipated.
Anticipated Liberalization: Exogenous (-) and Endogenous (--) Innovation

Panel A: Trade cost, $\tau$

Panel B: Innovation by large exporters, $q(z)$ high $z$

Panel C: Exporters domestic share, $sD$
Anticipation Effects: Response of Endogenous Innovation

Summary

- Anticipation effects for innovation: rise in innovation precedes reduction in trade costs if the latter is anticipated.
- Implies that the rise in share of exporters in domestic sales precedes the reduction in trade costs
- What has been viewed as “exogenous” differences in productivity driving export market selection can also have an endogenous component
Temporary Trade Liberalization and Sunk Export Costs

- We now introduce **sunk** costs of exporting, but stick to the case of **exogenous innovation**.
- The following figure contrasts the permanent and temporary trade liberalization case for both our previous case with fixed export costs, and then with sunk export costs:
Sunk versus Fixed Export Costs: Role of Permanence of Trade Liberalization

Panel A: Trade cost, $\tau$

- Temporary
- Permanent

Panel B: Fixed Export Costs, Exporters domestic share, $s_D$

Panel C: Sunk Export Costs, Exporters domestic share, $s_D$
Temporary Trade Liberalization and Sunk Export Costs

Summary

- With sunk costs, the initial response of trade volumes to the same decrease in trade costs is substantially larger when the reduction is perceived to be permanent.

- Note that this distinction is irrelevant without sunk costs (as shown in Panel B).
The following figure considers an anticipated, permanent reduction in trade costs in the parametrizations of the model with exogenous innovation, with fixed costs of exporting and with sunk costs of exporting.
Anticipated Trade Liberalization, Exogenous Innovation, Fixed costs (-) and Sunk Export Costs (--)
Anticipation Effects: Sunk Costs and Option Values

Summary

- Uncertainty and sunk export costs generate option values, and anticipation effects of trade liberalization affects these option values ahead of actual changes in trade costs.

- Implies that, with sunk export costs, the rise in share of exporters in domestic sales precedes the reduction in trade costs.
Conclusion

- We have characterized dynamic responses to trade liberalization in GE models of industry productivity dynamics with both endogenous innovation and trade.

  - Can address recent evidence regarding firms' response to liberalization over time.
    - Including: entry/exit, export, and innovation decisions.

- These decisions generate endogenous dynamics for aggregate productivity, trade volumes, and consumption.
  - Amplifies comparative advantage of exporters vs non-exporters.

- Long lasting adjustment dynamics arise from combination of firm productivity dynamics and endogenous export market selection.

- Timing of trade liberalization shape endogenous dynamics.