Firm Dynamics in Trade

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Introduction: Two broad sets of questions

- Firm-level dynamics and trade
  - Try to understand: exporter life cycle, entry, exit
  - Roles of technology, trade barriers, uncertainty, learning
- Aggregate outcomes shaped by firm-level dynamics
  - How do the welfare gains from trade liberalization depend on firm-level behavior?
  - Do models with firm-level dynamics help us understand the long- and short-run behavior of aggregate trade in response to changes in tariffs or over the business cycle?
  - What explains the delayed response of the trade balance to a change in the real exchange rate?

Outline

1. Data
   - What do the micro data tell us about firm export dynamics?
   - What macro dynamics might firm-level dynamics help us understand?

2. Partial equilibrium: The canonical model
   - Dynamic firm-choice problem
   - Ability of the model to match the data
   - Extensions to the model

3. General equilibrium aggregation
   - Embed PE model in general equilibrium
   - How do aggregate dynamics depend on firm-level dynamics?

Data

- Focus on Colombia
- Dynamic linked panel that is easy to access and widely used.
  Information on total sales and custom data by destination.
  - Data and codes available at: `kimjruhl.com` (not yet!)
- Regression tables
  - We suppress standard errors here, but they are in the paper
  - The usual notation: $^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$

Decomposing aggregate trade

- Firms $i = 1 \ldots n$ export. Firms $i = n+1 \ldots N$ do not.
- Decompose aggregate export-sales ratio into three margins
  1. Extensive margin (first term on rhs)
  2. Intensive margin (second term on rhs)
  3. Exporter size premium (third term on rhs)

$$\frac{\sum_{i=1}^{n} exports_i}{\sum_{i=1}^{N} sales_i} = \frac{n}{N} \times \frac{n^{-1} \sum_{i=1}^{n} sales_i \times exs_i}{n^{-1} \sum_{i=1}^{n} sales_i} \times \frac{n^{-1} \sum_{i=1}^{n} sales_i}{N^{-1} \sum_{i=1}^{N} sales_i}$$

- Use this framework to organize our empirical study
- First, take exports to the world, later exports by destination country

Decomposing aggregate trade

	All values are expressed as percentages							
	United States			Colombia		Colombia 100+		
Panel A	1987	2007	log diff.	1983	2013	1983	2013	log diff.
Export/sales	6.3	11.6	61.1	5.2	14.6	5.2	13.9	97.7
Extensive	43.2	63.0	37.7	10.8	24.6	36.5	59.8	49.5
Intensive	9.9	15.5	44.9	12.8	23.5	10.8	20.3	62.8
Premium	148.0	119.5	−21.4	374.9	252.4	132.1	114.2	−14.6
Panel B								
Starter rate	10	–		2.0	5.5	6.9	13.8	
Stopper rate	17	–		16.5	16.1	11.9	10.1	

- Trade barriers fall $\rightarrow$ trade grows
- Extensive and intensive margins grow
- Newer, smaller exporters $\rightarrow$ size premium falls

The extensive margin

- Large literature on drivers of entry and exit
- Laws-of-motion for exporters and total firms

$$n_{t+1} = \gamma_{t+1}^{\text{starter}} \left[\delta_{nt}(N_t - n_t) + N_{E,t+1}\right] + \left(1 - \gamma_{t+1}^{\text{stopper}}\right) \left[\delta_{xt} n_t\right]$$

$$N_{t+1} = \delta_{nt}(N_t - n_t) + \delta_{xt} n_t + N_{E,t+1},$$

- δ are the survival rates; N_E mass of newly created firms
- $\gamma^{\text{starter}}, \gamma^{\text{stopper}}$ are the export starter and stopper rates
  - increasing starter rate, flat stopper rate $\rightarrow$ increasing extensive margin (previous table)

Fact #1. Past export participation is the main predictor of current export participation.

	Export status$_t$			
	(1)	(2)	(3)	(4)
log sales$_t$	0.129***	0.053***	0.053***	0.043***
exporter$_{t-1}$		0.640***	0.593***	0.636***
exs$_{t-1}$			0.217***	0.220***
N	76,662	76,662	76,662	76,662
adj. R^2	0.330	0.618	0.622	0.610

Columns 1–3 include industry and year fixed effects. Column 4 includes year fixed effects.

- Linear probability model
- Size (measured by sales) matters less when controlling for history
- Coefficient on exporter$_{t-1} < 1$

Fact #2. Exporter exit rates fall with past export intensity and time in the export market.

	Stopper$_t$	
	(1)	(2)
log sales$_{t-1}$	0.003	
log exports$_{t-1}$	–0.032***	–0.022***
starter$_{t-1}$	0.244***	0.207***
starter$_{t-2}$	0.119***	0.084***
log destinations$_{t-1}$		–0.075***
log months$_{t-1}$		–0.100***
Market	World	Country
N	15,631	324,297
adj. R^2	0.157	0.319

Column 1 includes industry and year fixed effects. Column 2 includes destination-year fixed effects.

- Linear probability model
  - Col 1: Total exports
  - Col 2: Exports by country
  - months = # months with positive shipments
  - destinations = # countries served
- Export volume, **not overall size**, decreases exit prob.
- Newer exporters more likely to exit

Fact #3. The exporter entry rate is low but is increasing in size and past export activity.

	Starter$_t$		
	(1)	(2)	(3)
log sales$_{t-1}$	0.027***	0.028***	
log destinations$_{t-1}$			0.004***
exporter$_{t-2}$	0.214***	0.185***	0.158***
exs$_{t-2}$		0.211***	
Market	World	World	Country
N	47,289	47,289	20,598,517
adj. R^2	0.109	0.111	0.036

Columns 1&2 includes industry and year fixed effects. Column 2 includes destination-year fixed effects.

- Linear probability model
  - Col 1&2: Total exports
  - Col 3: Exports by country
  - destinations = # countries served
- Entry rates are low
- Size matters but previous experience is more important
- Previous export experience raises the probability of *reentry* by 20 percentage points

The intensive margin

- Facts #1–#3 about the extensive margin: Does the firm export at all?
- Now we turn to the intensive margin: Conditional on exporting, how much does the firm export?
- Measure it as the exports-to-total-sales ratio

$$exs_{it} = \frac{\text{exports}_{it}}{\text{sales}_{it}}$$

- Regress this on lagged *exs*, and time since entry or until exit

$$exs_{it} = \alpha + \sum_{k=0}^{K} \rho_{-k}\, exs_{i,t-k} + \beta_1 d_{it}^{\text{starter}} + \beta_2 d_{it}^{\text{exporter}} + \sum_{k=0}^{K} \theta_k d_{i,k}^{\text{stopper}} + \mu d_{it}^{\text{start,stop}} + \varepsilon_{it}$$

The intensive margin

	Export-total-sales ratio$_t$			
	(1)	(2)	(3)	(4)
exporter$_t$	0.216***	0.242***	0.073***	0.240***
starter$_t$		–0.093***	0.070***	–0.078***
stopper$_{t+1}$		–0.087***	–0.028***	–0.097***
starter$_t$,stopper$_{t+1}$		0.063***	0.012	0.045***
exs$_{t-1}$			0.543***	
exs$_{t-2}$			0.190***	
stopper$_{t+2}$				–0.040***
stopper$_{t+3}$				–0.028***
N	60,668	60,668	60,668	37,072
Adj. R^2	0.358	0.378	0.692	0.381

Fact #4. Export intensity rises with time in the export market.

- Average intensity of 20 percent. Home bias at the firm level.
- New and soon-to-exit exporters sell less
- Export intensity is persistent

- Overall life cycle pattern is one of entry, growth, shrinkage, exit
  - Use coefficients to trace out pattern

Exporter life cycle

Export to total-sales ratio

	1	2	3	4	5	6	7	Long run
Starter	14.3	15.1	18.2	20.1	21.7	22.9	23.9	27.4
	–7	–6	–5	–4	–3	–2	–1	
Stopper	22.1	23.2	21.8	19.5	18.8	19.1	16.9	

- Long-run ratio is $exs_{LR} = \alpha/(1 - \sum_{k=0}^{K} \rho_{-k})$
- A new exporter grows by 50 percent in its first five years
- An exiting firm shrinks by about 30 percent in its last five years

Further decomposing the intensive margin

- We have been considering a firm's total exports to the world
- With transactions-level data, we can learn more about how a firm's total exports grow/shrink
  - By adding or subtracting markets (countries, e.g. Arkolakis 2016)
  - By shipping more or less frequently (e.g. Alessandria, Kaboski, Midrigan 2010)
- This takes some of the intensive margin growth and turns it into extensive margin growth
- This data let us think more about how the exporting technology works.

Destinations

- Previous facts largely unchanged at the destination level
- Fact #2: Stopper rates
  - Similar role for history
  - Stopper rates falling in number of months a firm ships
  - Stopper rates falling in number of markets served
- Fact #3: Starter rates
  - Past exporting good predictor of entry into a country
  - Starter rates rising in number of markets served
- Export costs may depend on access to other markets. . .

Destinations

- Fact #4: Intensive margin growth (exports, not exports-sales ratio)
  - New exporters in a market grow fast for only one year: starter$_{t-2}$ insignificant or negative

Export growth by destination

	Δ_t log export			
	(1)	(2)	(3)	(4)
starter$_{t-1}$	0.245***	0.039**	0.410***	0.068**
stopper$_{t+1}$	−0.948***	−0.280***	−1.042***	−0.251***
starter$_{t-2}$	−0.011	−0.021*		
log exports$_{t-1}$	−0.184***	−0.147***		
log destinations$_{t-1}$	−0.077***	−0.071***	0.070**	
log months$_{t-1}$	0.033***		0.071***	
log total exports$_{t-1}$	0.105***	0.077***	−0.135***	−0.089***
Δ_t log months		1.034***		0.988***
Δ_t log destinations				0.146***
Market	Country	Country	World	World
N	131,282	131,282	50,192	50,192
adj. R^2	0.116	0.445	0.128	0.474

Columns 1 and 2 include country-year fixed effects. Columns 3 and 4 include year fixed effects.

Shipment frequency

Fact #5: Most firms import or export a few times per year. Shipment size increases, and frequency decreases, in distance. Trade grows through more frequent and larger shipments.

- A role for inventories
- Suggests that exporters face fixed per-shipment costs

Micro data: Summary

1. Past export participation is the main predictor of current export participation.
2. Exporter exit rates fall with past export intensity and time in the export market.
3. The exporter entry rate is low but is increasing in size and past export activity.
4. Export intensity rises with time in the export market.
5. Most firms import or export a few times per year. Shipment size increases, and frequency decreases, in distance. Trade grows through more frequent and larger shipments.

Aggregate effects of firm-dynamics

- Firm-level dynamics are slow: The small size, high exit rate, and slow growth of new exporters means that exports are reallocated away from existing exporters over time.
- Next table: What is the cumulative impact of new exporters?
  - After 12 months, 20 percent of exporters are new
  - After 60 months, 36 percent of exporters are new
  - After 12 months, entrants account for 11 percent of exports
  - After 60 months, entrants account for 21 percent of exports

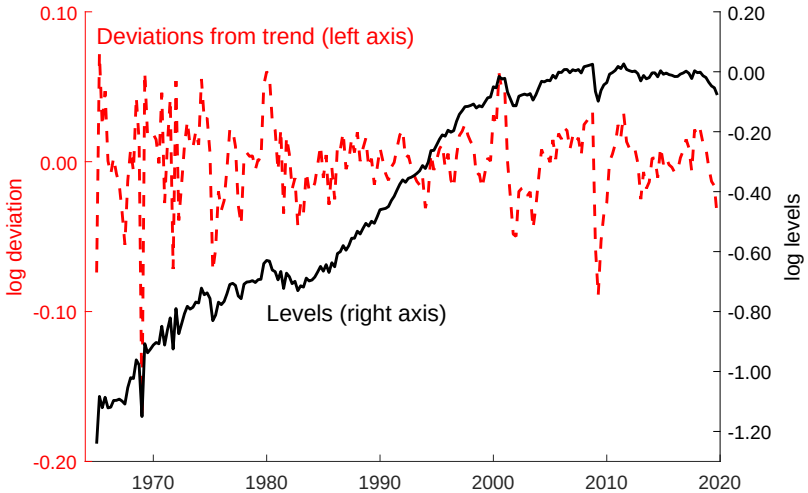
	continuation rate				entrants' share		
Window (months)	1	6	12	36	12	36	60
Panel A: Number							
Firm			80	76	20	30	36
Firm, balanced			85	83	15	21	24
Firm*	64	65	59	41	41	54	63
Firm-destination*	54	63	60	46	40	54	62
Panel B: Export value							
Firm			89	91	11	18	21
Firm, balanced			94	98	6	8	7
Firm*	95	98	98	96	2	7	11
Firm-destination*	85	95	94	92	6	13	19

Panel A: *Continuation rate* is the share of exporters that remain exporters across two windows, e.g., 80 percent of firms who exported in a 12-month window export in the next 12-month window. *Entrant's share* is the share of total exporters accounted for by entrants, e.g., 30 percent of exporters are firms that did not export 36 months prior. Panel B: The columns are defined analogously but for export volumes, rather than firm counts. * From the customs transaction-level data.

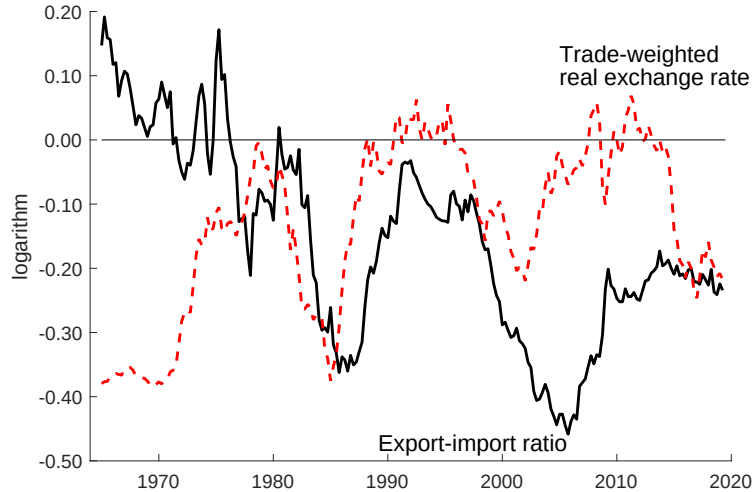
Aggregate data

- Aggregate trade tends to respond slowly to changes in trade barriers or business-cycle conditions

Aggregate trade in the United States



U.S. trade (exports plus imports)



U.S. net trade and real exchange rate

- Levels respond slowly to liberalization (left panel, solid line)
  - GATT/WTO rounds in 1967, 1979, 1994
- Levels respond with a lag to relative prices (right panel)

Aggregate data

- Aggregate trade tends to respond slowly to changes in trade barriers or business-cycle conditions

  Fact #7: The long-run response of aggregate trade volumes to changes in trade policy is larger than the short-run response.

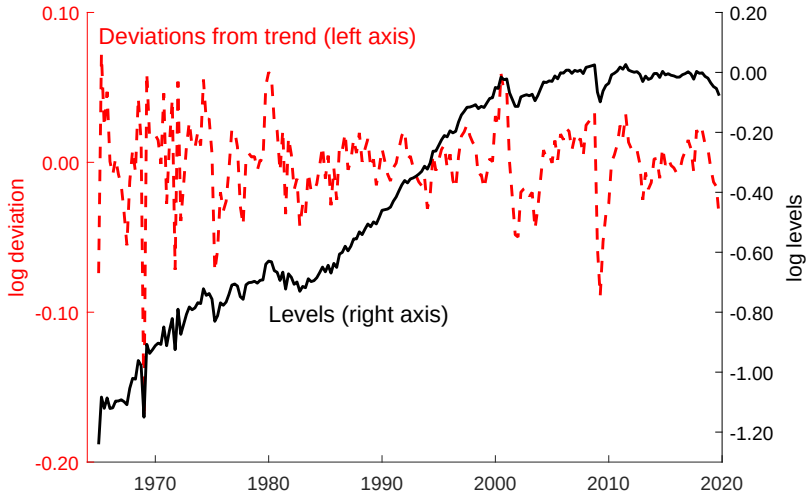
Aggregate data

- Aggregate trade tends to respond slowly to changes in trade barriers or business-cycle conditions

  Fact #7: The long-run response of aggregate trade volumes to changes in trade policy is larger than the short-run response.

- . . . but not always. The 2008 recession featured a sharp fall in trade.

Aggregate trade in the United States



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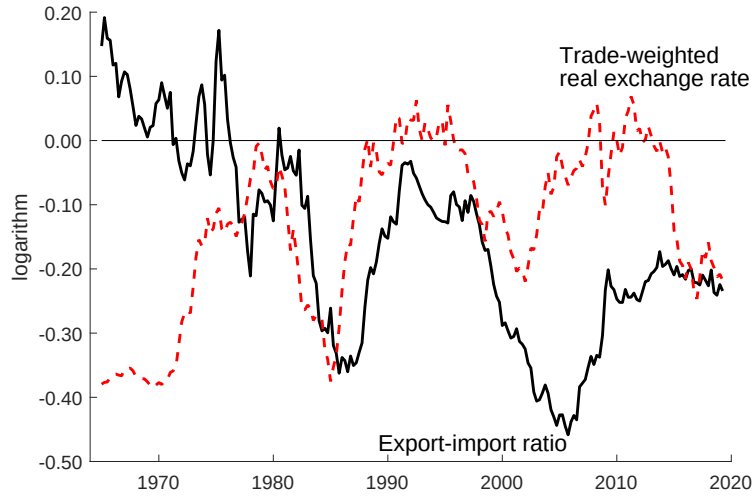


U.S. net trade and real exchange rate

- Levels respond slowly to liberalization (left panel, solid line)
  - GATT/WTO rounds in 1967, 1979, 1994
- Levels respond with a lag to relative prices (right panel)
- At business-cycle frequencies, trade can fall sharply (left panel, dashed)
  - 2008 recession, coronavirus response

Understanding aggregate dynamics

- Time-varying slow and fast responses of trade to shocks are enormous challenges for static models
- Interpreted through a “gravity” model, these dynamics load onto the error term and we learn nothing about them. The dynamics are interpreted as shocks to trade barriers.
- Explicitly dynamic models allow us to learn more about the nature of these “shocks” and the structure of export costs/technologies

Sunk export entry cost models: overview

- Early development: Baldwin (86, 89); Baldwin & Krugman (89); Dixit (89ab) in partial equilibrium
- Considered dynamics following exchange rate shocks: focusing on the nonlinear TB-RER relationship (as in previous figure)
  - Option value models: Dixit (89)
  - Structural IO: Roberts & Tybout (97); Das, Roberts & Tybout (07)
  - Learning vs. selection: Clerides, Lach & Tybout (98)
- General equilibrium models largely focused on aggregate fluctuations & trade policy
  - Alessandria & Choi (07,19ab); Ruhl (08)
  - Alessandria & Choi (14ab); Alessandria, Choi, & Ruhl (13); Impullitti, Irrazabal, & Opromola (13)

Model outline

1. Firm decision problem in partial equilibrium
2. Success and challenges
3. Extensions
4. Embed the decision problem into general equilibrium

Model: decision problem

- Three key features in firm-level models of trade
  1. An investment technology
  2. An uncertain future return to that investment
  3. A depreciation process of that investment

Model: decision problem

- Consider a firm i making a decision to export: $x_{it} = \{0, 1\}$

$$V_t = \max E_t \sum_{s=t}^{\infty} \frac{1}{1 + r_s} x_{is} \left(\pi_{is}(\cdot) - f_{is}(\cdot)\right)$$

- Fixed export costs: $f_{it}\left(\epsilon_{it}, x_{it-1}, x_{it-2}, ..., x_{it-k}\right)$ depend on random variable and experience

- Flow profits: $\pi\left(x_{it}, z_{it}, d_{it}\right)$
  - z_{it} = variables related to productive efficiency
  - d_{it} = variables related to foreign demand for firm i's
  - Assumes constant returns to scale, otherwise $z_{it}\left(s_{it}, d_{it}\right)$ where s_{it} is sales at home

Model: foreign demand

- Assume a firm charging price p_{it} sells

$$d_{it}\left(p_{it}\right) = \omega_{it}\left(p_{it}\frac{\tau_t \xi_t \tilde{\xi}_{it}}{P_t}\right)^{-\theta} D_t$$

- Common factors: market size (D_t), real exchange rate (P_t), ad-valorem tariff (τ_t), iceberg trade costs (ξ_t)
- Idiosyncratic factors: demand shifter (ω_{it}) and $\left(\tilde{\xi}_{it}\right)$ e.g., shipping/distribution technology
  - Two idiosyncratic factors redundant, combine into ξ_{it}
  - No congestion effects on distribution
- CES framework is common

Fixed costs

- Since Baldwin & Krugman (89) & Roberts & Tybout (97) assume
- $f(\epsilon_{it}, x_{it-1})$: only $t-1$ export status matters (full depreciation of market-access investment)
- $f(\epsilon_{it}, 1) < f(\epsilon_{it}, 0)$: cost of entering exceeds continuation cost (upfront investment in market access)
- fixed cost lowers iceberg cost from $\xi = \infty$ to $\xi < \infty$ (return on investment)
- When fixed trade cost only depends on last period's export status the fixed cost and history variable are redundant.
- A richer model in which fixed costs depend on experience requires tracking longer history

Uncertainty

- Microeconomic $(z, \xi, f(\epsilon_{it}, x_{it-1}))$
  - Let z, ξ follow AR1 process $\left(\rho_z, \sigma_z^2, \rho_\xi, \sigma_\xi^2\right)$
  - Let stochastic component follow $\epsilon_{it} \sim \log \text{Normal}\left(0, \sigma_\epsilon^2\right)$
  - Often assume aspect of ξ is learned upon entry (Learning)
- Macroeconomic
  - Processes for exchange rate (P_t) & demand (D_t) depend on equilibrium concept
  - In partial equilibrium (P, D) are exogenous AR processes
  - In general equilibrium, (P, D) depend on shocks and transmission (can be highly non-linear)
  - For tariffs no standard

Bellman Equation

- The firm solves a standard discrete-choice problem

$$V_t\left(x_{it-1}, z_{it}, \xi_{it}, f_{it}\right) = \max\left\{ V_t^0\left(x_{it-1}, z_{it}, \xi_{it}, f_{it}\right), V_t^1\left(x_{it-1}, z_{it}, \xi_{it}, f_{it}\right)\right\}$$

- To solve this problem we will need to know
  - A firm's survival probability (δ_{it})
  - The interest rate (r_t)
- The ts capture non-stationary functions from aggregate shocks
  - Most partial equilibrium models assume stationarity

Bellman Equation

- Value of not exporting

$$\begin{aligned} V_t^0\left(x_{it-1}, z_{it}, \xi_{it}, f_{it}\right) &= \pi_t\left(0, z_{it}, \xi_{it}\right) \\ &\quad + \delta_{it} \underset{z,\xi,f}{\mathrm{E}} \frac{1}{1+r_{t+1}} V_{t+1}\left(0, z_{it+1}, \xi_{it+1}, f_{it+1}\right) \end{aligned}$$

- Value of exporting

$$\begin{aligned} V_t^1\left(x_{it-1}, z_{it}, \xi_{it}, f_{it}\right) &= \pi_t\left(1, z_{it}, \xi_{it}\right) \\ &\quad + \delta_{it} \underset{z,\xi,f}{\mathrm{E}} \frac{1}{1+r_{t+1}} V_{t+1}\left(1, z_{it+1}, \xi_{it+1}, f_{it+1}\right) \end{aligned}$$

- Focus on a stationary environment for now (drop ts)

Decision Rules

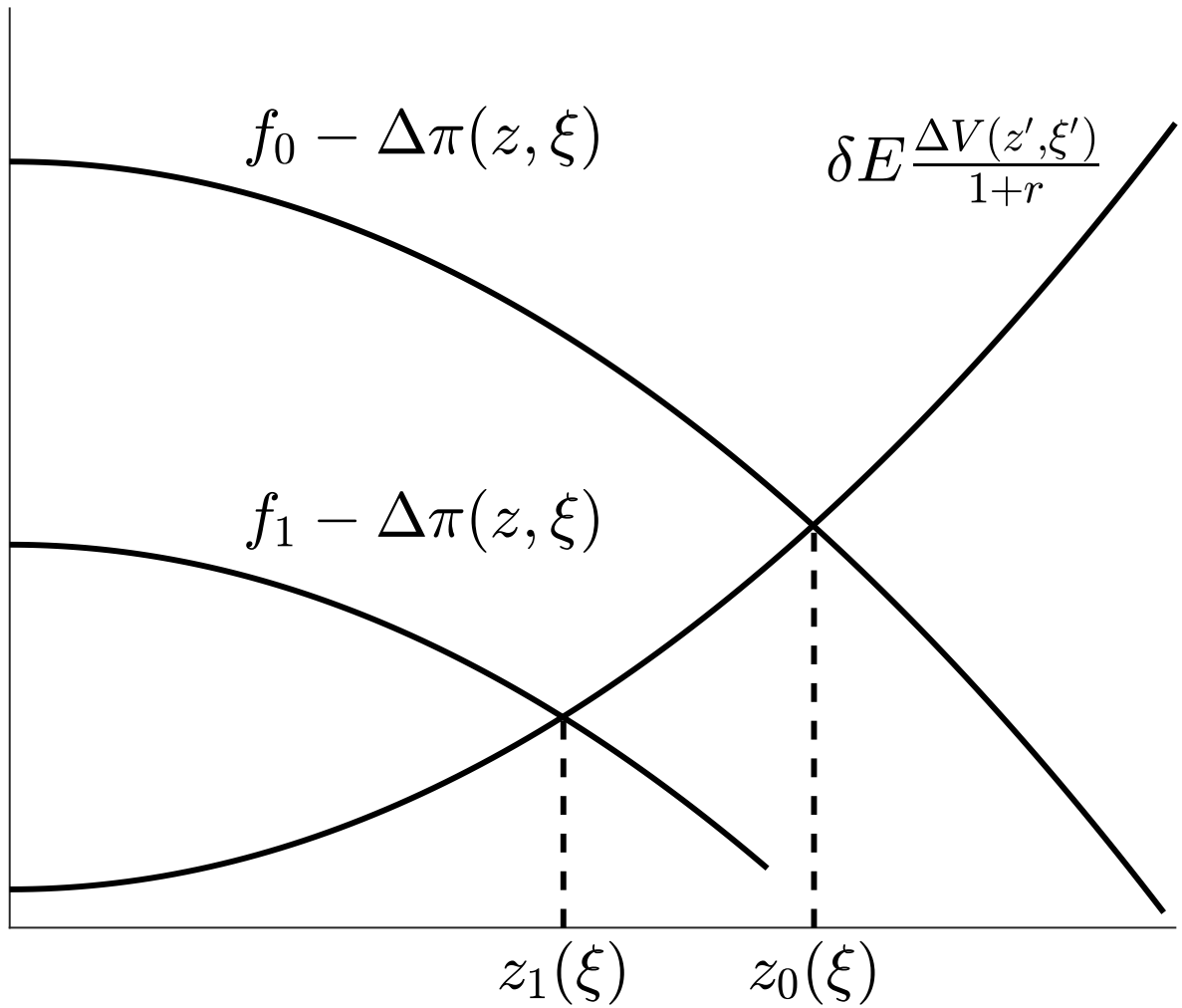
- Assume 1) f is deterministic (i.e. $\sigma_\epsilon = 0$) and 2) export and domestic profit increasing in z
- Optimal policy is a cutoff rule $z_m(\xi)$ s.t. $x_{it} = 1$ iff $z \geq z_m(\xi)$

$$f_m - [\pi(1, z_m(\xi), \xi) - \pi(0, z_m(\xi), \xi)] = \frac{\delta}{1+r} E \begin{bmatrix} V^1(z', \xi', f_1) \\ -V^0(z', \xi', f_0) \end{bmatrix}$$

$$f_m - \Delta\pi(z_m(\xi), \xi) = \frac{\delta}{1+r} E[\Delta V(z', \xi', f_1, f_0)]$$

- The LHS is the current cost of exporting net of increased profits
- The RHS is the future benefit (increase in market value of the firm)

Breakevens


$f_0 - \Delta\pi(z, \xi)$
$\delta E \frac{\Delta V(z', \xi')}{1+r}$
$f_1 - \Delta\pi(z, \xi)$
$z_1(\xi)$
$z_0(\xi)$

The gain in firm value from exporting

- The RHS of the break-even condition
- The upward sloping line in the figure
- Depends on fixed costs and persistence of shock
- The slope is increasing in the persistence of shocks
  - It determines both how long and how much you earn exporting
- The intercept is mostly determined by the gap between $f_0 - f_1$
  - If $f_0 = f_1$ then $\Delta V = 0$
  - Holding f_1 constant, $\frac{\partial \Delta V}{\partial f_0} > 0$

The current cost of exporting

- The LHS of the break-even condition
- The downward sloping lines in the figure

- Holding fixed ξ profit decreases in z
  - Exporting more profitable to more productive firms

Distributions

- The cutoff thresholds and the process for (z, ξ) determine the measure of firm types $\mu(z, \xi, f)$
- $\mu(z, \xi, f_0)$ [$\mu(z, \xi, f_1)$] denotes the beginning of period non-exporters [exporters]
- The measures of current nonexporters and exporters

$$N_N = \int_{\xi} \int_{0}^{z_0(\xi)} \mu(z, \xi, f_0) + \int_{\xi} \int_{0}^{z_1(\xi)} \mu(z, \xi, f_1)$$

$$N_X = \int_{\xi} \int_{z_0(\xi)}^{\infty} \mu(z, \xi, f_0) + \int_{\xi} \int_{z_1(\xi)}^{\infty} \mu(z, \xi, f_1)$$

- The export participation share is $N_X / (N_N + N_X)$

Laws of motion

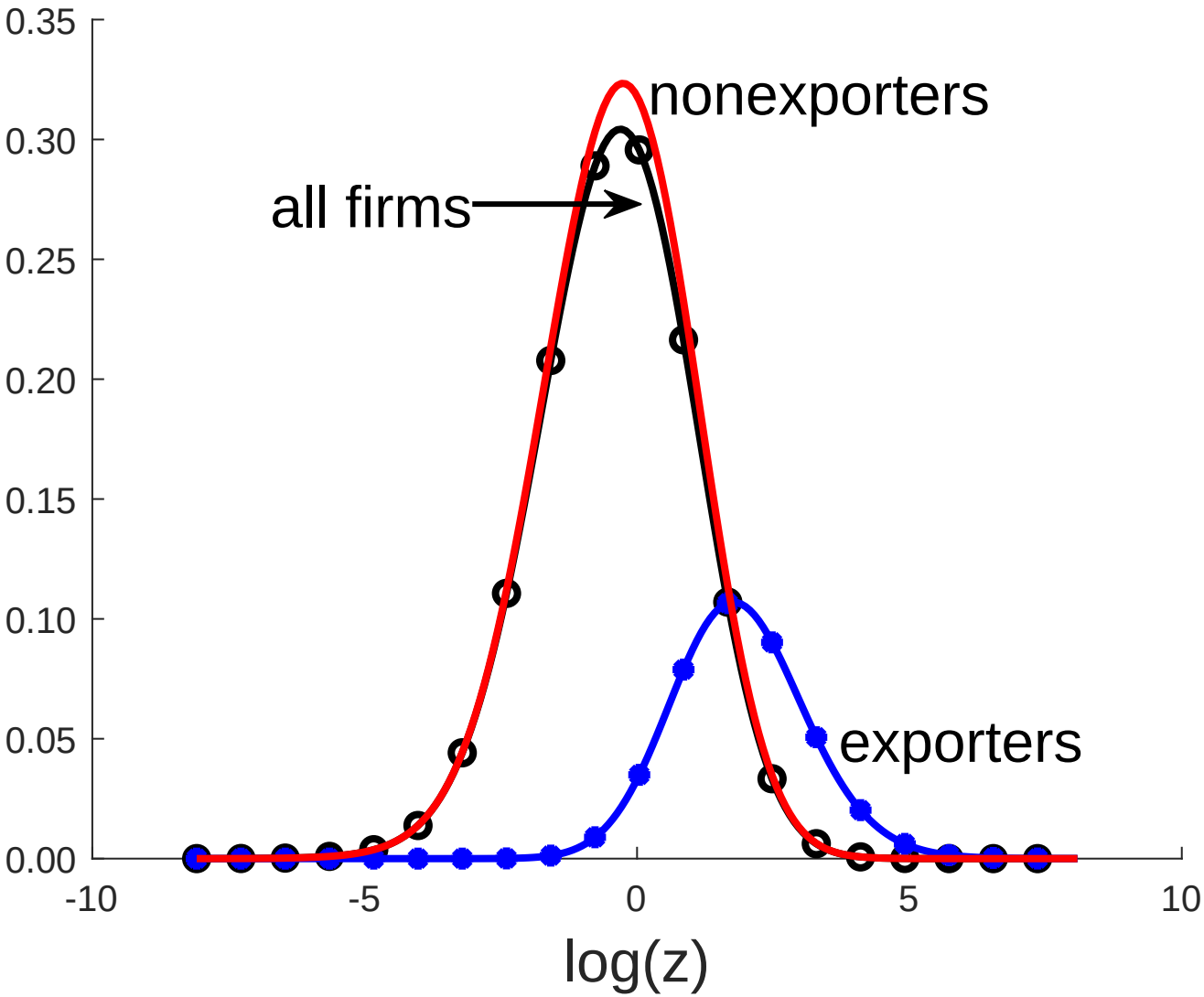
$$N'_X = \delta_{X,X} \Pr(\text{continue}) N_X + \delta_{N,X} \Pr(\text{start}) N_N$$

$$N'_N = \delta_{X,N} [1 - \Pr(\text{continue})] N_X + \delta_{NN} [1 - \Pr(\text{start})] N_N + N_E$$

- A more careful exposition would focus fully on

$$\mu'(z, \xi, f) = T(\mu(z, \xi, f))$$

Distributions



Properties

- Crucial outcome of dynamic decision: $z_1(\xi) < z_0(\xi)$
  - Harder to break into exporting than to stay
- This generates
  - **Exporter hysteresis:** Firms continue exporting after conditions deteriorate
  - **Low exit rate:** Exporters will delay exiting to avoid paying the entry cost again
  - **Export Premium:** Exporters are larger than nonexporters
    - Increasing in the average fixed cost
    - Falling in the difference in fixed costs

Sensitivity

- Consider impact of changes in current and future primitives abstracting from GE interactions
- Let's look at
  1. Trade barriers
  2. Uncertainty

Trade costs and Tariffs

- Consider three possible reductions in either (ξ, τ)
  1. Current trade costs temporary
  2. Future trade costs permanent
  3. Current and future trade costs

Temporary current

- Lowering today's tariff will shift up the $\text{LHS}_m(z)$
- Increasing entry and decreasing exit
- Through law of motion, trade will remain persistently high, only gradually mean-reverting

Permanent future

- Lowering tariff in the future will shift up the $\text{RHS}_m(z)$
- Increasing entry and decreasing exit today
- Trade grows in advance of liberalization
- Through law of motion trade will increase gradually

Permanent current

- Lowering tariff in the current will shift up the $\text{RHS}_m(z)$ and $\text{LHS}_m(z)$
- Combination of previous two shocks
- Increasing entry and decreasing exit today
- Trade grows by more on impact
- Through law of motion trade will increase gradually.

Uncertainty

- As in typical models with non-convexities, uncertainty matters [Dixit & Pindick, 94]. Consider
  1. Current dispersion in productivity, $\sigma_z \uparrow$ [temporary]
     - Does not affect thresholds, but does affect distribution of ability today
     - Thicker tails $\rightarrow$ more entry and more exit
     - Volume of trade should increase since condition mean of productivity $\uparrow$
  2. Future uncertainty/dispersion, $\sigma'_z \uparrow$ [permanent]
     - Shift up and flattening of the marginal gain curve
     - Entry and exit fall, ambiguous effect on trade today and in the future

Success and Challenges

- Successes
  - Persistent export participation (fact #1)
  - Low export and entry rates (facts #3,4)
  - Dynamic macro adjustment (fact #7)
- Challenges
  - New exporters (too productive at entry, too likely to continue, and export intensity too high)
  - Connection in exporting across markets
  - High re-entry rates in monthly and longer frequencies
- Causes
  - Exporting technology too simple (parsimonious): f_0, f_1, ξ
  - Need to shift more investment into post-entry period and reduce depreciation

Resolutions: Starting and stopping

- Small new-exporters & low continuation rate
  - Let $f_1(t_e)$ be a decreasing function of t_e=age in market
- High re-entry data
  - Annual: Let firm that stops re-enter with $f_R \in [f_1, f_0]$
  - Monthly: set $f_0 = f_1$, hold goods in inventories at a cost abroad

Resolution: Export intensity dynamics

- Modify iceberg cost structure so that they fall with experience
  - Alessandria (2013) assume enter at $\xi_H > \xi_L$ and then markov transition between states
  - Reflects improvements in export distribution technology
- Alternatively could accumulate customers or build habit (Fitzgerald et al., 2016; Piveteau, 2016; Ruhl and Willis, 2017; Rodrigue and Tan, 2019)
- Both approaches have investments in improving market after entry, not just maintaining access
- Backloads profits which leads to lower estimates of entry costs.
- When growth process is uncertain, this makes it more likely to exit

Extensions

- Input adjustment frictions
  - Slow down overall growth
  - Lower the value of exporting (all else equal, less participation)
  - If applied to both domestic and export production, do not effect export intensity dynamics
  - **Physical capital adjustment (convex and nonconvex)**: Alessandria and Choi (2007), Riaño (2011), Rho and Rodrigue (2015), Rho and Rodrigue (2016)
  - **Labor adjustment**: Many static models with labor frictions Coşar et al. (2016) (search model + trade model), Fajgelbaum (2013)

Extensions

- Importers
  - Do import dynamics suggest sunk costs and irreversible investments?
  - Yes. Lu et al. (2016), Ramanarayanan (2017), Imura (2019)
- Importers and exporters
  - Many exporters are also importers. Allow import sunk-costs, too.
  - Kasahara and Lapham (2013) estimate strong complementarity between the two activities — correlated sunk costs

Extensions

- Innovation and growth
  - Atkeson and Burstein (2010): innovation not important for aggregate exports; entry and innovation offset each other
  - Aw et al. (2011): estimate a model of R&D and find complementarity between innovation and exporting
  - Many models with static export decisions and dynamics from innovation. Potential to study innovation in models with dynamic exporting (Alvarez et al., 2013, Perla et al., 2013, Sampson, 2014).

Extensions

- Financial frictions
  - Similar to input frictions: lowers value of exporting, creates second state variable for the firm (wealth); firms grow slowly
  - Kohn et al. (2016): working capital constraint
  - Brooks and Dovis (2019): endogenous vs. exogenous debt constraints imply different behavior. Data suggest endogenous debt constraints.

Extensions

- Learning: firm's can learn about their productivity or demand in the foreign country
  - Eaton et al. (2014), Timoshenko (2015), Arkolakis et al. (2018): Jovanovic-style learning within a market. Uncertainty means new exporters start small and many exit early. Those who find out they are good grow fast.
  - Albornoz et al. (2012), Schmeiser (2012): learning across markets leads to sequential export entry into markets.

General equilibrium

- Embed the firm-decision problem into general equilibrium
- Why general equilibrium?
  - Account for feedback through prices
  - Feedback typically dampens effects vis a vis partial equilibrium
- Also allow for free entry of firms, physical capital, intermediate goods

General equilibrium: Overview

- Two symmetric countries (Foreign with asterisk)
- Same policies, technologies, assets (μ,μ^*,K,$K*$)
- GE models with international firm dynamics:
  - Alessandria & Choi (07, 14a, 14b), Ruhl (08), ACR (12), Impulliti, Irarrazabal, Oppromola (13JIE)
  - Imura (16), Steinberg (19), Mix (2019)
- With symmetric countries and trade liberalization, trade is balanced
  - Asymmetric countries or unilateral liberalization drive international capital flows
  - Alessandria et al. (2013)

Production

- The differentiated-variety production function

$$y_i = \left(z k_i^{\alpha} \ell_i^{1-\alpha} \right)^{1-\alpha_x} x^{\alpha_x}$$

  - k is physical capital
  - x intermediate good (a composite of varieties)
  - Inputs chosen flexibly

Final good production

- Constant returns to scale, perfect competition
- Firm (a good) state is $s = (z, \xi, f)$

$$Y_t = \left[\int y_{Ht}(s)^{\frac{\theta-1}{\theta}} \mu_t(s)\, ds + \int y_{Ft}(s)^{\frac{\theta-1}{\theta}} \mu_t^*(s)\, ds \right]^{\frac{\theta}{\theta-1}}$$

- Final good used for consumption, physical capital investment, and intermediate goods (x)

$$Y_t = C_t + K_{t+1} - (1-\delta)K_t + X_t$$

- Parametric elasticity is θ but this will not be the aggregate elasticity to a change in tariffs. The aggregate elasticity depends on the extensive margin response.

Household's Problem

$$\max_{C_t, K_{t+1}} \; E \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma}$$

$$\textbf{s.t.} \;\; C_t + K_{t+1} = w_t L_t + (1 + r_t - \delta_k) K_t + T_t + \Pi_t \qquad t = 0, 1, \ldots$$

$$C_t > 0, \;\; K_0 = \overline{K}$$

- L is the household's labor endowment ($L = 1$,
- r is the rental rate of capital,
- w is the wage,
- T is the lump-sum rebate of tariff revenue,
- Π is the profit earned by domestic firms.

Calibration

- Calibrate the model to the United States in the early 1990s
- Assume the United States is in a stationary equilibrium
- Break the parameters space into two sets
  - Ones chosen without solving for the model's equilibrium
  - Ones that require solving for the model's equilibrium

External calibration

- Calibrate the model to the United States in the early 1990s
- Not calibrated, but common in the literature
  - $\theta = 5$, $\sigma = 1$
- Calibrated (target)
  - $\tau = 0.10$ (U.S. average tariff rate)
  - $\beta = 0.96$ (real interest rate)
  - $\delta_k = 0.1$ (U.S. physical capital depreciation rate)
  - $\alpha = 0.3$ (U.S. capital share in income)
  - $\alpha_x = 0.80$ (U.S. $\frac{\text{gross ouput}}{\text{value added}}$)

External calibration, continued

- Calibrated (target)
  - $\rho_z = 0.835$, $\sigma_z = 0.188$ (typical values)

    A serious calibration fits an AR(1) to a panel of firm-level output data.
  - $\mu_e = -0.296$ ()
  - $\chi_0 = 13.47$, $\chi_1 = 2.17$ ()

Internal calibration

- Previous parameters common to many models
- Follow a method of simulated-moments procedure
- Moments are informative of the intensive and extensive margins
- No one-to-one mapping between moments and parameters

Moment	Value	Parameter	Calibrated value
Export-sales ratio	8.3	f_e	7.95
Participation rate	22.3	f_0/f_e	0.026
Exporter premium	2.8	ξ_H	1.88
Exporter intensity	13.1	ξ_L	1.09
Stopper rate	15.9	ρ_ξ	0.93

Export technology

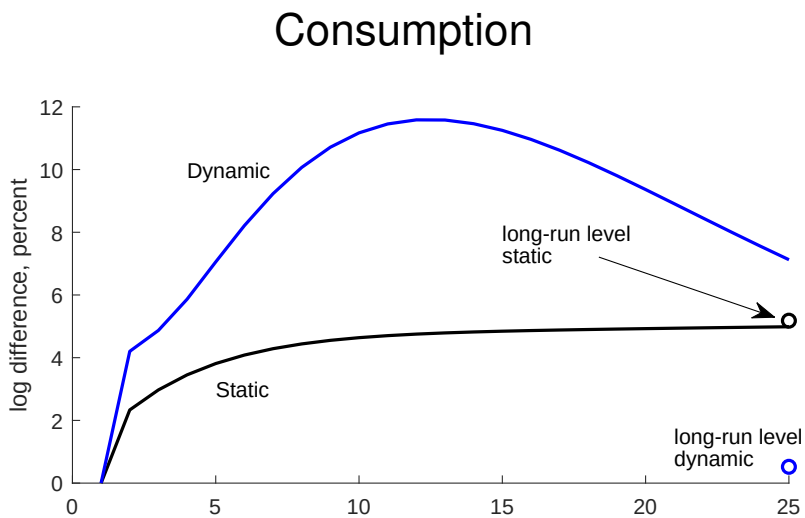
Moment	Value	Parameter	Calibrated value
Export-sales ratio	8.3	f_e	7.95
Participation rate	22.3	f_0/f_e	0.026
Exporter premium	2.8	ξ_H	1.88
Exporter intensity	13.1	ξ_L	1.09
Stopper rate	15.9	ρ_ξ	0.93

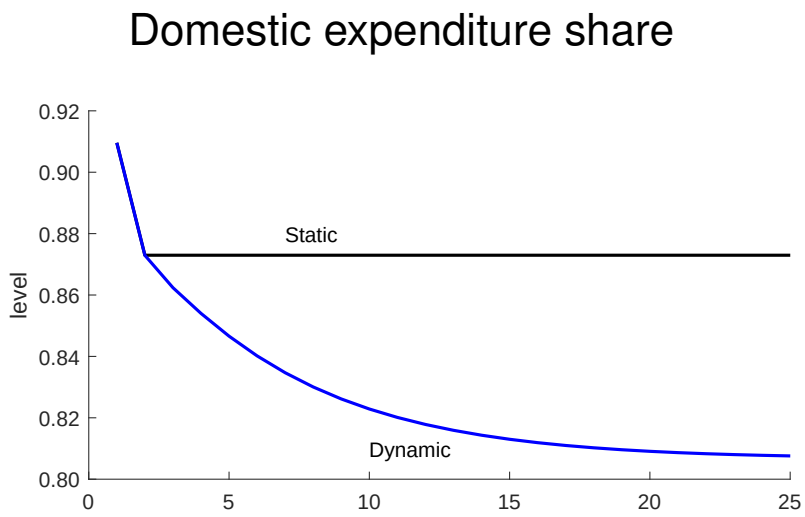
- Cheap to create an exporter compared to creating a new plant
- Big difference between being a good and bad exporter
- Export type is persistent
- Exporter intensity driven by share of good and bad exporters
- Big picture: Large gain to becoming a good exporter. Not easy to do.
  $\rightarrow$ high stopper rates; low export participation

A tariff liberalization

- Start in stationary equilibrium
- Surprise cut in tariffs to $\tau = 0$ in both countries
- Perfect foresight for rest of time
- This is not how trade liberalization works!
  - Negotiated over time, phased in; sometimes unilateral
- Easy to phase-in a path of tariffs with perfect foresight
  - Here, focus on the firm dynamics; abstract from other sources
- More challenging to have uncertainty over liberalization and compute transition path
  - Worth trying to figure out...

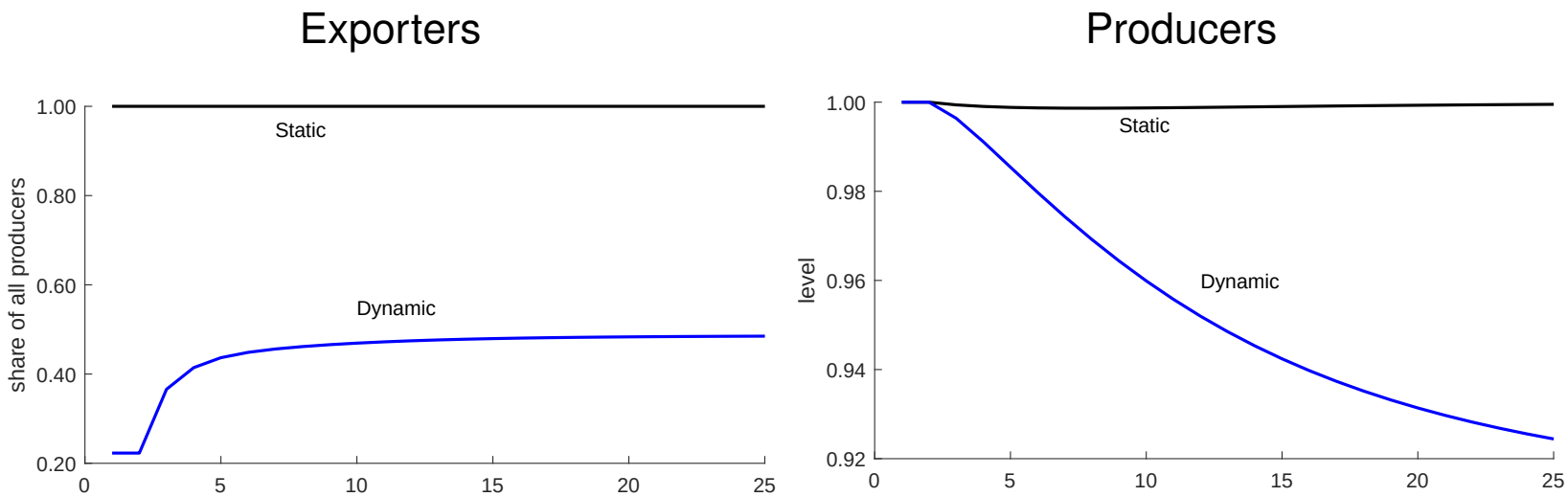
Tariff liberalization





- Focus on Dynamic model (blue lines)
- Consumption overshoots its long-run level
- Aggregate trade share (1-domestic share) grows slowly

Tariff liberalization

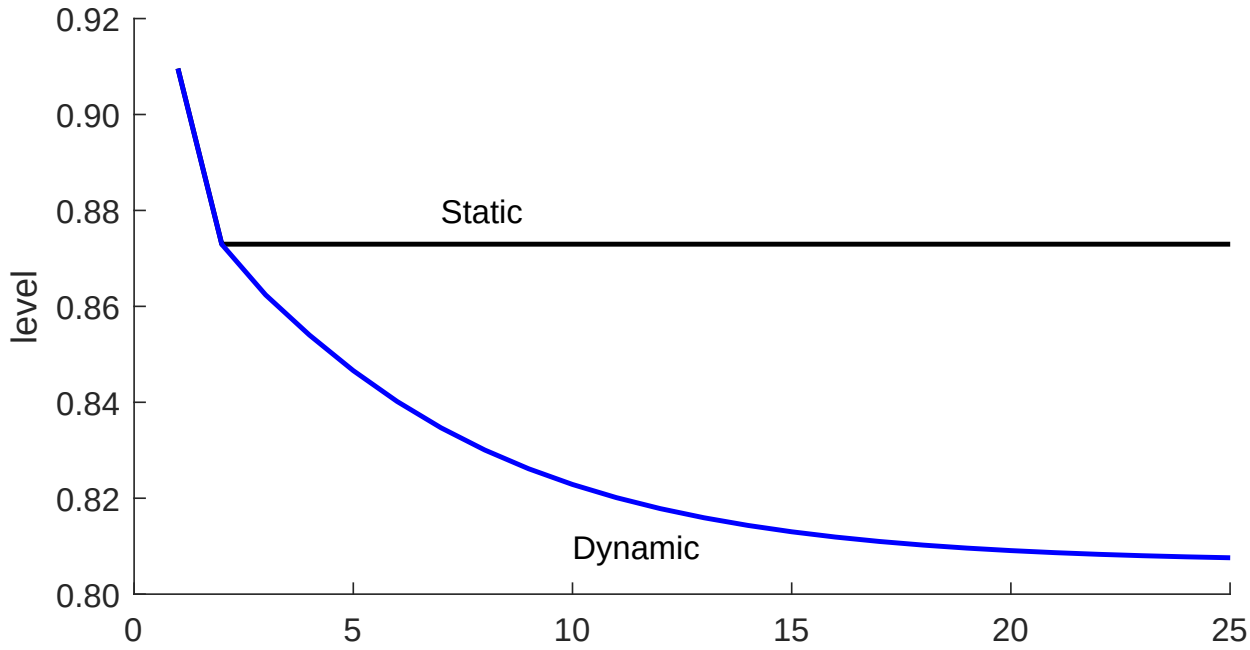


- Exporters increase gradually, which feeds into aggregate dynamics
- Number of producers decreases

Trade liberalization with firm dynamics

- Initial equilibrium has too many firms
  - Imports are relatively expensive
  - Value variety, so create domestic firms
- Liberalization
  - Buy cheaper varieties from abroad
  - Need fewer domestic firms
  - Consume resources that would have gone to firm creation $\rightarrow$ overshooting in consumption
  - Takes time to build of exporters; aggregate trade grows slowly

Aggregate trade

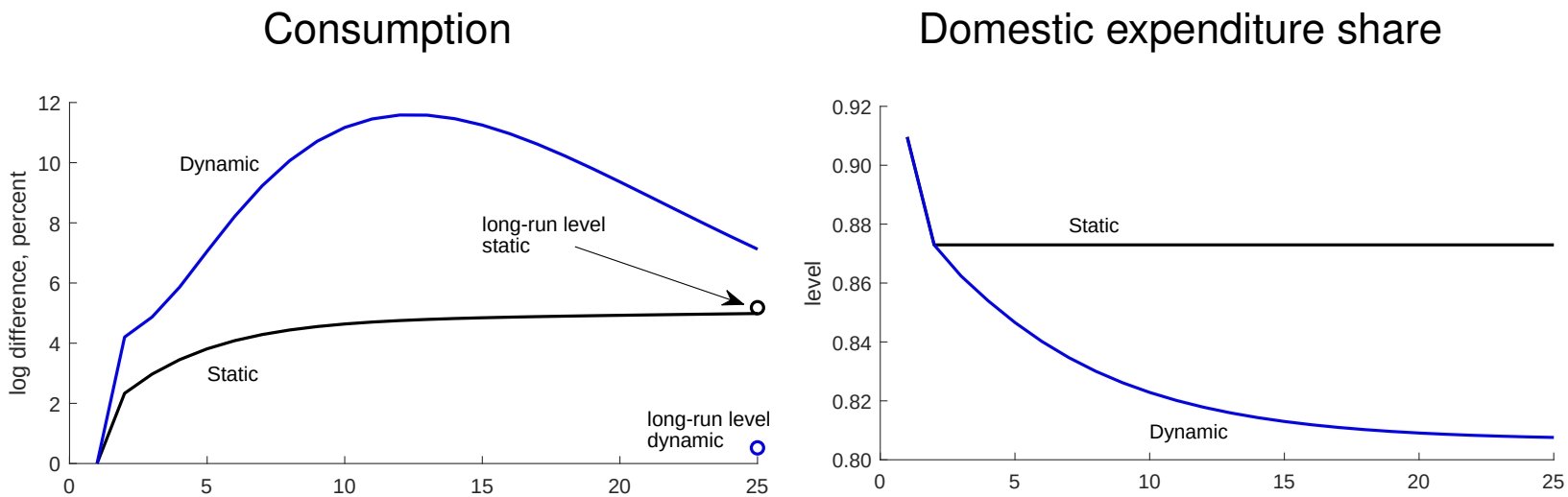


- Initial jump downward is increase in trade on the intensive margin (θ)
- Slow change afterward is from 1) more exporters 2) exporters stay in market longer and more become good exporters
- Policy change induces change in export technology

A model without trade dynamics

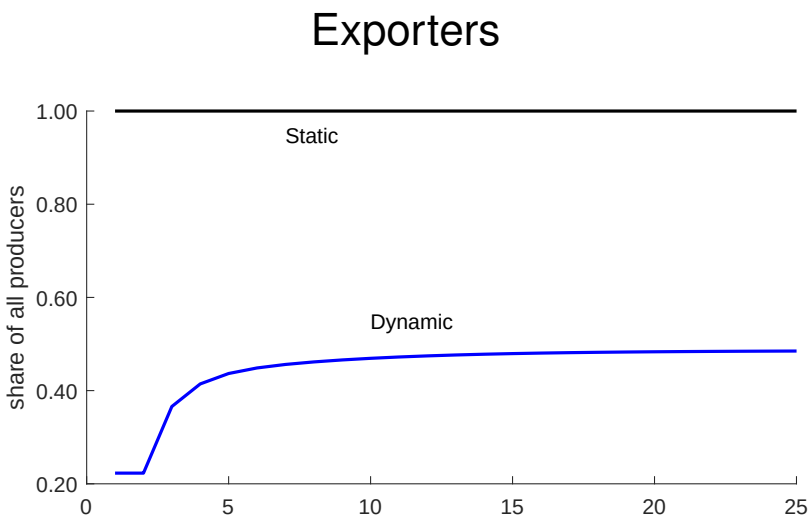
- Static model except for capital accumulation
- Set $f_0 = f_1 = 0$; every firm exports
  - No extensive margin dynamics
  - No forward-looking decision
- Set $\xi_H = \xi_L = 1.62$ (match agg. export-sales ratio)
  - No intensive margin dynamics
  - Value consistent with the literature (home-bias)
- This is essentially Krugman (1980) with heterogeneous productivity

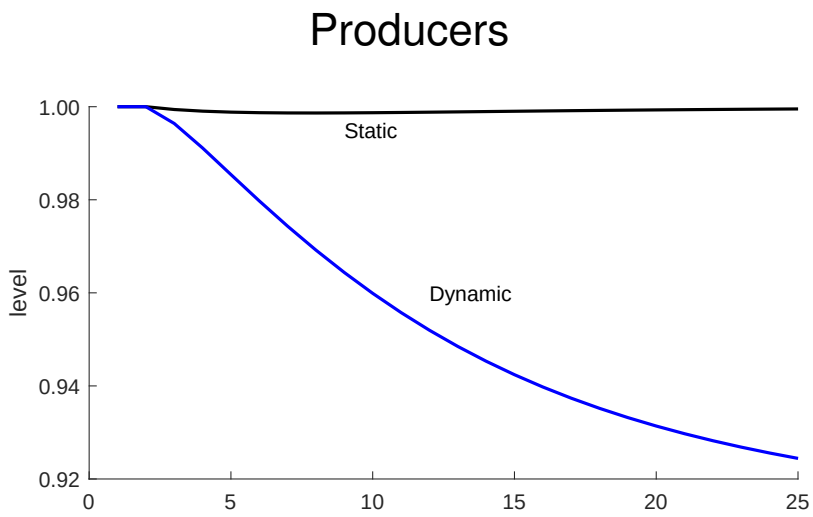
Tariff liberalization: Static



- Consumption grows monotonically and relatively fast
  - Close to long-run level after 25 periods
- Aggregate trade share jumps to new level
  - Short and long run elasticities are identical

Tariff liberalization: Static





- No change in exporters
- Number of producers temporarily dips but no long-run change

	Static exporters	Dynamic exporters
Long-run trade elast.	4.00	9.22
ΔC_{ss}	5.18	0.48
Δ Welfare	4.62	6.66
Δ Welfare/ΔC_{ss}	0.89	13.81

- Static elasticity is $\theta - 1$
- Dynamic elasticity captures exten. margin and better export tech.
- Static model delivers higher steady-state consumption...
- ...but Dynamic model has higher welfare (from overshooting)

- Static "sufficient-statistic" approach is not a good approximation to the dynamic model