Risky Gravity[⋆]

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August 2023

[⋆]The views expressed here are those of the authors and they do not necessarily reflect official positions of the International Monetary Fund.

Motivation

- Countercyclical risk premia widely viewed as an important source of fluctuations
- Abrupt crisis (e.g. GFC and the COVID-19 crises) are associated with trade collapses
- The canonical trade model assigns no role to risk and risk premia
- This paper: proposes a simple extension of the canonical model of trade to overcome this omission

Our paper: Theory

- Canonical trade model (Chaney, 2008) integrated in the consumption CAPM model
- Firms are owned by domestic risk averse households
- Risk is priced using the household's stochastic discount factor (IMRS)
- Selecting into a new export destination more attractive if demand acts as a hedge for household aggregate consumption growth risk

- Key prediction:
  - Risk affects the extensive margin $\rightarrow$ higher risk lowers the probability of exporting to that destination

Our paper: Empirics

- Argentinean firm-level export data
- Risk is found to directly affect the extensive margin of trade
- Empirical evidence on intensive margin consistent with life-cycle model extension
- Cross-sectional heterogeneity in risk helps explain bilateral trade flows
- Fluctuations in risk premia contribute to trade collapses in periods of heightened uncertainty

Literature

- Ramondo and Rappoport (2010) and Ramondo et al. (2013) study how risk affects the internationalization of the firm (but focus is on FDI)
- Handley and Limão (2017) study trade policy uncertainty
- Esposito (2020) and De Sousa et al. (2020) consider how risk affects trade investment choices by firms, but without considering equilibrium discount factors
- Uncertainty has been shown to affect sharply the behavior of the firm over the business cycle (Bloom, 2009), and this mattered during the GFC trade collapse (Novy and Taylor, 2020)

Model
Setup

- We consider a world economy with $N + 1$ countries: Home, and N export destinations
- Consumers in each country derive utility from the consumption of differentiated varieties of goods from S different sectors, $s = 1, ..., S$
- Firms have heterogeneous productivity levels
- Firms chose which countries to export to before demand conditions are known

Model
Household preferences and asset pricing

- Stand-in household has preferences given

$$\mathcal{U}_t = \mathbf{E}_t \sum_{i=0}^{\infty} \beta^i u\left(\mathcal{C}_{t+i}\right),$$
$$\mathcal{C}_t = \prod_{s=1}^{S} \left(\int_{\Omega_{st}} c_{st}\left(v\right)^{1-1/\epsilon_s} dv \right)^{\mu_s \epsilon_s/(\epsilon_s - 1)}$$

- Its budget constraint reads

$$\mathcal{C}_t + \left(\mathcal{B}_t/\mathcal{R}_t\right) + \int_j \mathcal{Q}_{jt}\xi_{jt} dj = WL_t + \mathcal{B}_{t-1} + \int_j \left(\pi_{jt} + \mathcal{Q}_{jt}\right)\xi_{jt-1} dj$$

Model
Household preferences and asset pricing

- The fundamental asset pricing equation is

$$\begin{aligned}\mathcal{Q}_{jt} &= \mathbf{E}_t\left[\frac{\beta u'\left(\mathcal{C}_{t+1}\right)\left(\pi_{jt+1}+\mathcal{Q}_{jt+1}\right)}{u'\left(\mathcal{C}_t\right)}\right] \\ &= \mathbf{E}_t\left[\mathcal{M}_{t+1}\left(\pi_{jt+1}+\mathcal{Q}_{jt+1}\right)\right],\end{aligned}$$

where $\beta u'\left(\mathcal{C}_{t+1}\right)/u'\left(\mathcal{C}_t\right)=\mathcal{M}_{t+1}$ is the stochastic discount factor (SDF)

Model
Monopolistic firms pricing

- The main elements are
  - An "iceberg" cost τ_i and a fixed cost f_i to export to destination $i = 1, \ldots N$
  - Monopolistic competitive markets (iso-elastic preferences $\Rightarrow$ constant mark-up)

$$p_{jist} = \frac{\tau_i W}{\varphi_j} \left(\frac{\epsilon_s}{\epsilon_s - 1} \right)$$

  - Firm productivity φ_j, randomly drawn from the Pareto distribution with CDF

$$\mathbf{F}(\varphi) = 1 - \varphi^{-\alpha_s},$$

where $\alpha_s > \epsilon_s - 1$

Model

Demand Shocks

- Optimal quantity demanded by country i

$$q_{jist}(v) = Z_{ist} p_{jist}(v)^{-\epsilon_s},$$

with Z_{ist} an exogenous demand shifter which follows a random walk in logs, $Z_{ist+1} = Z_{ist} \exp(\varepsilon_{ist+1})$

- Variable profits by firm j in sector s obtained from exporting to country i are

$$\tilde{\pi}_{jit+1} = \lambda_s Z_{ist} \left(\frac{\varphi_j}{W \tau_i} \right)^{\epsilon_s - 1} \exp(\varepsilon_{ist+1}),$$

where $\lambda_s = \epsilon_s^{-\epsilon_s} (\epsilon_s - 1)^{\epsilon_s - 1}$

- As an upshot, variable profits are also a random walk in logs

$$\tilde{\pi}_{jit+1} = \tilde{\pi}_{jit} \exp(\varepsilon_{ist+1})$$

Model
Exporting and the pricing of the firms

- Household owned firms are priced using the equilibrium SDF
- Firms must decide which destinations to export to one period in advance
- Recursive problem solved by the firm

$$\mathcal{Q}_{jt} = \max_{\{d_{jit}\}_{i=1}^{n}} \mathbf{E}_t \left[\mathcal{M}_{t+1} \left(\sum_{i=1}^{n} d_{jit} \pi_{jit+1} + \mathcal{Q}_{jt+1} \right) \right]$$

where $d_{jit} = 1$ if firm j selects country i as export destination

Model
Exporting and the pricing of the firms

- Hence, the Bellman equation solving the firm's problem is

$$\mathcal{Q}_{jt} = \sum_{i=1}^{n} d^{\star} \left[\mathbf{E}_t \left(\tilde{\pi}_{jit+1} \right) \mathbf{E}_t \left(\mathcal{M}_{t+1} \right) + \text{cov}_t \left(\tilde{\pi}_{jit+1}, \mathcal{M}_{t+1} \right) - f_i \right] + \mathbf{E}_t \left(\mathcal{M}_{t+1} \mathcal{Q}_{jt+1} \right),$$

  with $\text{cov}_t \left(\tilde{\pi}_{jit+1}, \mathcal{M}_{t+1} \right)$ the priced risk, $d^{\star} = \mathrm{I} \left(\varphi_j \geq \bar{\varphi}_{ist} \right)$

- $\mathcal{M}_{t+1} = \beta \left(\mathcal{C}_t / \mathcal{C}_{t+1} \right)^{\rho} \simeq \beta \left(1 - \rho g_{t+1} \right)$, with g_{t+1} the growth rate of aggregate consumption

Model

Exporting and the pricing of the firms

- With power utility function, the Bellman equation simplifies to

$$\mathcal{Q}_{jt} = \sum_{i=1}^{n} \mathrm{I}\left(\varphi_j \geq \bar{\varphi}_{ist}\right)\left[\beta\lambda_s Z_{ist}\left(\frac{\varphi_j}{W\tau_i}\right)^{\epsilon_s - 1}\left(1 - \rho\sigma_{\varepsilon,g}^{is}\right) - f_i\right] + \mathbf{E}_t\left(\mathcal{M}_{t+1}\mathcal{Q}_{jt+1}\right),$$

where

$$\sigma_{\varepsilon,g}^{is} = \mathrm{cov}_t\left(\varepsilon_{ist+1}, g_{t+1}\right)$$

The extensive margin under risk

- Optimal firm behavior yields a threshold productivity level

$$\bar{\varphi}_{ist} = \left[\frac{f_i / \left(1 - \rho \sigma^{is}_{\varepsilon,g}\right)}{\beta \lambda_s Z_{ist}} \right]^{1/(\epsilon_s - 1)} W \tau_i$$

- The probability that firm j selects country i as an export destination is given by

$$\begin{aligned} \text{Prob}\left(d_{jit} = 1\right) \equiv \mathbf{P}_{jit} &= 1 - \mathbf{F}\left(\bar{\varphi}_{ist}\right), \\ &= \left[\frac{\beta \lambda Z_{ist}}{f_i / \left(1 - \rho \sigma^{is}_{\varepsilon,g}\right)} \right]^{\alpha_s/(\epsilon_s - 1)} \left(W \tau_i\right)^{-\alpha_s} \end{aligned}$$

- Or in logs

$$\ln \mathbf{P}_{jit} \simeq \text{constant} + \left(\frac{\alpha_s}{\epsilon_s - 1} \right) Z_{ist} - \left(\frac{\alpha_s}{\epsilon_s - 1} \right) f_i \underbrace{- \left(\frac{\alpha_s}{\epsilon_s - 1} \right) \rho \sigma^{is}_{\varepsilon,g}}_{\text{extensive margin risk elasticity}} - \alpha_s \ln(W \tau_i)$$

Model predictions
Proposition I

- The probability that a firm exports to a given destination (extensive margin) is decreasing in the destination's risk factor, $\sigma^{is}_{\varepsilon,g}$. The extensive margin risk elasticity is

$$\text{risk elasticity} = -\left(\frac{\alpha_s}{\epsilon_s - 1}\right)$$

- In absolute value, it increases with mark-ups (falls with ϵ_s), and falls with the productivity dispersion (increases in α_s)
- The intensive margin of trade in not affected by risk Intensive Margin

Measuring risk

- We impose a factor structure to the demand innovations

$$\varepsilon_{ist+1} = \zeta_s \eta_{it+1},$$

where

$$\varepsilon_{ist+1} = \ln\left(X_{ist+1}/X_{ist}\right),$$
$$\eta_{it+1} \simeq \ln\left(\overline{X}_{it+1}/\overline{X}_{it}\right),$$

with $\overline{X}_{it} = \sum_{s=1}^{S} X_{ist}$ Agg exports

Measuring risk

- Risk varies across sectors and export destinations, and is obtained as

$$\text{cov}_t\left(\tilde{\pi}_{jit+1}, \mathcal{M}_{t+1}\right) = \sigma^{is}_{\varepsilon,g} = \text{cov}_t\left(\varepsilon_{ist+1}, g_{t+1}\right)$$

$$\text{cov}_t\left(\tilde{\pi}_{jit+1}, \mathcal{M}_{t+1}\right) = \sigma^{is}_{\varepsilon,g} = \text{std}\left(\hat{\varepsilon}_{ist+1}\right) \times \text{std}\left(g_{t+1}\right) \times \varrho\left(\hat{\eta}_{it+1}, g_{t+1}\right)$$

- Assume $\text{std}\left(g_{t+1}\right) = 1$

$$\text{cov}_t\left(\tilde{\pi}_{jit+1}, \mathcal{M}_{t+1}\right) = \sigma^{is}_{\varepsilon,g} = \text{std}\left(\hat{\varepsilon}_{ist+1}\right) \times \varrho\left(\hat{\eta}_{it+1}, g_{t+1}\right)$$

- First- and second- moment shocks

$$\text{demand shock} \equiv \hat{\varepsilon}_{ist} = \Delta \ln X_{ist}$$

Data

- Argentinean firm-level export data
- For exports between 2002 and 2009 we observe
  - name of the exporting firm and sector
  - total value (in US dollars) of its FOB exports
  - the destination country
  - matched firm-level characteristics (AGE, SIZE)
- We combine this data with longer aggregate time-series on bilateral exports and macro variables

Figure: Volatility across sectors

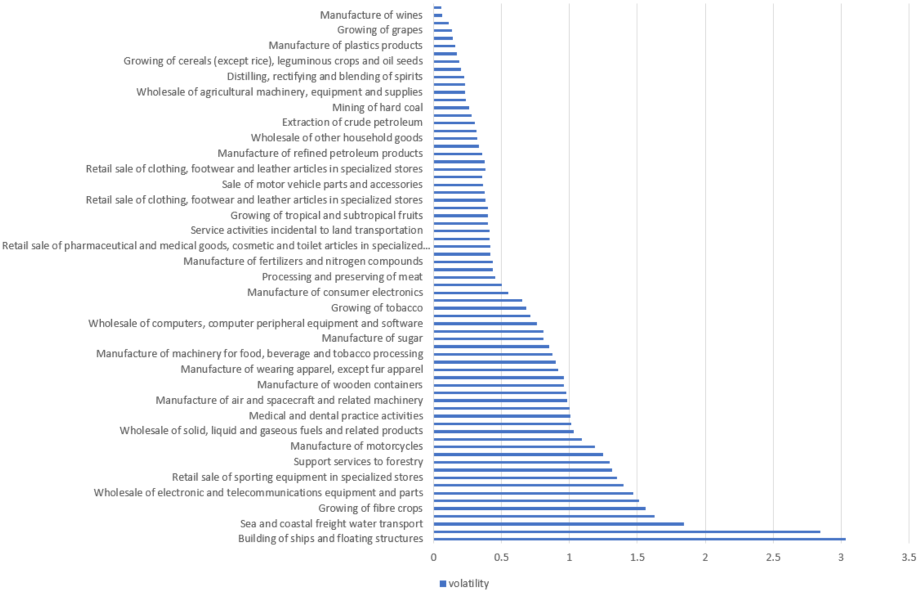
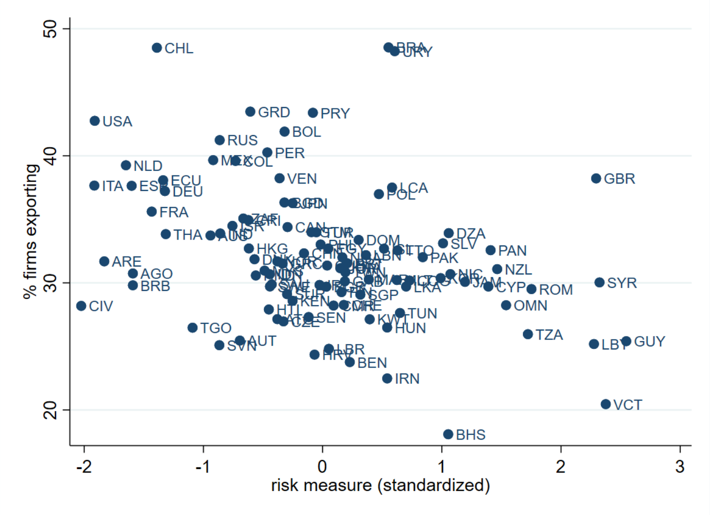


Figure: Risk and export selection



Baseline empirical specifications

- Baseline empirical specifications are as follows

$$d_{jit} = \delta' \mathbf{F}_{jit} + \beta_1 \mathbf{Risk}_{ji}^{(is)} + \beta_2 \mathbf{demand\ shock}_t^{(is)} + \varepsilon_{jit},$$

$$\ln(x_{jit}) = \omega' \mathbf{F}_{jit} + \gamma_1 \mathbf{Risk}_{ji}^{(is)} + \gamma_2 \mathbf{demand\ shock}_t^{(is)} + \varepsilon_{jit}.$$

- $\mathbf{F}_{jit}$ includes destination and firm-specific time-effects
- Proposition I $\rightarrow$ $\mathbf{H}_0$: $\beta_1 < 0$ and $\gamma_1 = 0$

Table: Trade and risk (extensive margin)

	(1)	(2)	(3)	(4)	(5)	(6)
DIST	−0.077***	−0.044***				
	(0.001)	(0.001)				
GDP	0.025***	0.012***				
	(0.001)	(0.000)				
SIZE	0.029***	0.017***				
	(0.001)	(0.000)				
AGE	0.076***	0.019***				
	(0.002)	(0.002)				
Risk	−0.144***	−0.078***	−0.058***	−0.035***	−0.101***	−0.062***
	(0.010)	(0.007)	(0.014)	(0.010)	(0.022)	(0.015)
Demand shock					0.017***	0.025***
					(0.001)	(0.001)
R-squared	0.085	0.240	0.305	0.394	0.310	0.416
Observations	667,185	583,660	644,564	563,857	487,833	487,833
Destination-year FE	no	no	yes	yes	yes	yes
Firm-year FE	no	no	yes	yes	yes	yes
Sector-year FE	yes	yes	no	no	no	no
Lagged dependent	no	yes	no	yes	no	yes

Table: Trade and risk (intensive margin)

	(1)	(2)	(3)	(4)	(5)	(6)
DIST	−0.212***	−0.055***				
	(0.007)	(0.003)				
GDP	0.199***	0.056***				
	(0.005)	(0.002)				
SIZE	0.302***	0.096***				
	(0.005)	(0.003)				
AGE	0.114***	−0.055***				
	(0.019)	(0.009)				
Risk	−0.098	−0.003	−0.435***	−0.177	−0.673***	−0.153
	(0.089)	(0.049)	(0.137)	(0.146)	(0.205)	(0.133)
Demand shock					0.262***	0.499***
					(0.009)	(0.017)
R-squared	0.272	0.697	0.518	0.858	0.567	0.872
Observations	260,124	155,381	236,772	46,193	136,763	46,193
Destination-year FE	no	no	yes	yes	yes	yes
Firm-year FE	no	no	yes	yes	yes	yes
Sector-year FE	yes	yes	no	no	no	no
Lagged dependent	no	yes	no	yes	no	yes
Selection adj.	no	no	no	yes	no	yes

Intensive margin considerations

- Prediction on intensive margin special case of benchmark model
- Selection issue (Fitzgerald and Haller, 2018): consider subsample (cols 4 and 6) including only firm-destination pairs with positive exports every year
- Life-cycle model extension (Foster et al., 2016) ▸ Life cycle
- Aggregation: average exports conditional on participation (average intensive margin)

Aggregation and the risk channel: Theory

- Tackle selection problem by doing aggregation to obtain the average intensive margin (AIM) [Bernard et al., (2012) and Fernandes et al., (2018)]
- Average value of firm's exports conditional on exporting to destination i is

$$\bar{\mathrm{x}}_{ist} = \frac{X_{ist}}{N_{ist}} = \beta^{-1}\left[\frac{\alpha_s\epsilon_s}{\alpha_s-(\epsilon_s-1)}\right]\left(\frac{f_i}{1-\rho\sigma^{is}_{\varepsilon,g}}\right),$$
$$\Rightarrow \ln\left(\bar{x}_{ist}\right) = \omega_s + \omega_i + \rho\sigma^{is}_{\varepsilon,g},$$

where $\omega_s = \ln\left(\alpha_s\epsilon_s\right) - \ln\left(\alpha_s - \epsilon_s + 1\right) - \ln\left(\beta\right)$ is a sector fixed effed, $\omega_i = \ln\left(f_i\right)$ is a destination fixed effect, and $\sigma^{is}_{\varepsilon,g}$ captures risk.

Aggregation and the risk channel: Empirics

Table: Risk and the average intensive margin

Risk	0.415***
	(0.128)
R-squared	0.412
Observations	50,770
Destination-year FE	yes
Sector FE	yes

Extensions and robustness

- Theory
  - Extension of baseline model to account for more realistic exporter growth dynamics (Foster et al., 2016) ▸ Life cycle
- Empirics
  - Estimation by firm size
  - Manufacturing firms only
  - Alternative samples
  - Probit model for extensive margin results
  - Estimate AIM using PPML

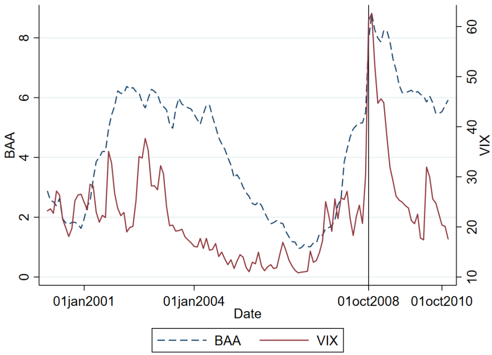
Time-varying risk-premia and the trade collapse

- Model predicts that the effect of heightened uncertainty is heterogeneous across export destinations
- Effect is large for export destinations which are "risky"
- This suggests D-in-D specification

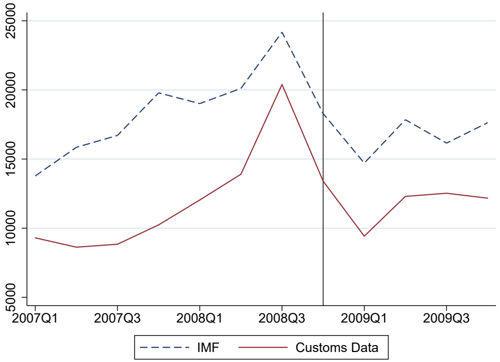
$$d_{jit} = \delta' \mathbf{F}_{jit} + \beta\, \mathbf{Crisis}_t \times \mathbf{Risk}_{ji}^{(is)} + \varepsilon_{jit}$$

where **Crisis**$_t$ is a dummy variable which takes value 1 in 2008Q4-2009Q3.

Snapshot of the GFC



(a) Risk premia



(b) Trade

Table: Time-varying risk premium and the trade collapse

	Extensive Margin		Intensive Margin	
	(1)	(2)	(3)	(4)
Crisis × Risk	-0.020**	-0.021**	-0.052	-0.088
	(0.009)	(0.009)	(0.080)	(0.134)
R-Squared	0.45	0.47	0.828	0.848
Observations	477,000	417,375	146,636	80,612
Destination-time FE	yes	yes	yes	yes
Firm-destination FE	yes	yes	yes	yes
Sector-time FE	yes	yes	yes	yes
Lagged dependent variable	no	yes	no	yes

Risk premium shocks

- In baseline specification risk is not time-varying
  - Results from normalizing $\text{std}\left(g_{t+1}\right)$ to unity ▸ Risk
- Allowing for time-varying dimension of risk

$$d_{jit} = \delta' \mathbf{F}_{jit} + \beta_1 \mathbf{Risk}_{ji}^{(is)} \times \mathbf{VIX}_t + \beta_2 \mathbf{Risk}_{ji}^{(is)} + \beta_3 \mathbf{VIX}_t + \varepsilon_{jit},$$

$$\ln\left(x_{jit}\right) = \omega' \mathbf{F}_{jit} + \gamma_1 \mathbf{Risk}_{ji}^{(is)} \times \mathbf{VIX}_t + \gamma_2 \mathbf{Risk}_{ji}^{(is)} + \gamma_3 \mathbf{VIX}_t + \varepsilon_{jit}.$$

Table: Time-varying measure of risk

	(1)	(2)	(3)	(4)	(5)	(6)
	Extensive Margin			Intensive Margin		
Risk × VIX	-0.004**	-0.003***	-0.002	-0.013	-0.012	-0.010
	(0.002)	(0.001)	(0.001)	(0.016)	(0.016)	(0.013)
Risk		-0.002	-0.004**		0.008	-0.026
		(0.002)	(0.002)		(0.019)	(0.019)
VIX			-0.012***			-0.063***
			(0.001)			(0.004)
R-squared	0.356	0.199	0.241	0.776	0.685	0.712
Observations	619,740	655,875	655,875	114,251	138,942	137,699
Destination-time FE	yes	yes	no	yes	yes	no
Firm-time FE	yes	no	no	yes	no	no
Exporter FE	no	no	yes	no	no	yes
Sector FE	no	yes	yes	no	yes	yes
Destination FE	no	no	yes	no	no	yes
Firm characteristics	no	yes	no	no	yes	no
Destination country GDP	no	no	yes	no	no	yes
Lagged dependent variable	yes	yes	yes	yes	yes	yes

Conclusion

- Risk can play an important role in driving trade fluctuations
- We extend Chaney (2008) model to include a role for risk
- Baseline prediction: risk affects extensive margin of trade directly
- Extension to the model to capture exporter's life-cycle can reconnect risk and intensive margin
- Empirically, risk is found to affect extensive margin
- Risk does not impact the intensive margin when considering long-term exporters
- Empirical evidence offers support for different impact of risk across younger and more mature exporters.

Extra Slides

Intensive margin

The value of exports by a firm is given by

$$\begin{aligned} x_{jist+1} = p_{jist+1} q_{ist+1} &= Z_{ist+1} p_{jist+1}^{1-\epsilon_s}, \\ &= \left(\frac{\epsilon_s}{\epsilon_s - 1}\right)^{1-\epsilon_s} \left(\frac{W\tau_i}{\varphi_j}\right)^{1-\epsilon_s} Z_{ist} \exp\left(\varepsilon_{ist+1}\right), \\ &= x_{jist} \exp\left(\varepsilon_{ist+1}\right). \end{aligned}$$

Go back

Aggregate Exports

Aggregate bilateral exports to country i in sector s at date $t+1$, given by

$$
\begin{aligned}
X_{ist+1} &= \Lambda_s Z_{ist}^{\alpha_s/(\epsilon_s-1)} \left(W\tau_i\right)^{-\alpha_s} \left(\frac{1-\rho\sigma_{\varepsilon,g}^{is}}{f_i}\right)^{\alpha_s/(\epsilon_s-1)-1} \exp\left(\varepsilon_{ist+1}\right), \\
&= X_{ist} \exp\left(\varepsilon_{ist+1}\right),
\end{aligned}
$$

with $\Lambda_s = \alpha_s \left(1 - 1/\epsilon_s\right)^{\epsilon_s - 1} \left(1 - \epsilon_s + \alpha_s\right)^{-1} \left(\beta\lambda_s\right)^{\alpha_s/(\epsilon_s-1)-1}$, a positive constant. ▸ Go back

Exporter's growth and the intensive margin

- Baseline model does not feature firm's growth
- Literature on exporters' growth dynamics shows that new exporters start small and then converge in size with older firms (Fitzgerald et al. 2023, Foster et al. 2016, Ruhl and Willis 2017)
- Assume 2 periods and a single export destination
- An exporting firm aged $a \in \{0, 1\}$ at date t is confronted with the demand function

$$q_a = Z_t c_a p_a^{-\epsilon},$$

where p_a is the price charged by the firm, Z_t is an exogenous stochastic demand shock, and c_a is an endogenous demand shifter that captures the experience of a firm aged a

Exporter's growth and the intensive margin

- Following Foster et al. (2016), customer base evolves according to

$$c_a = (1 - \delta)\, c_{a-1} + q_a,$$

  with $\delta \in (0, 1)$ the customer base depreciation rate
- Young firms have incentive to grow customer base by charging lower markups
- Old firms set price to achieve static markup $p_1 = (\tau W / \varphi) \frac{\epsilon}{(\epsilon - 1)}$

Exporter's growth and the intensive margin

- Price chosen by young firms

$$p_{t,0} = (1-\chi)\left(\frac{\epsilon}{\epsilon-1}\right)\left(\frac{\tau W}{\varphi}\right) + \chi\left(\frac{\epsilon}{\epsilon-1}\right)\left(\frac{\tau W}{\varphi}\right)\rho\sigma_{\varepsilon,g},$$

  with χ the probability of exporter's survival

- If χ=0, young exporters charge the optimal static mark-up and risk is irrelevant
- If $\chi > 0$, and $\sigma_{\varepsilon,g}$=0, young firms charge a lower markup
- Incentive to charge lower markup is dampened if $\sigma_{\varepsilon,g} > 0$

Intensive Margin Extensions

Measuring risk

- Estimate risk measure

$$\text{cov}_t\left(\tilde{\pi}_{jit+1}, \mathcal{M}_{t+1}\right) = \sigma_{\varepsilon,g}^{is} = \text{std}\left(\hat{\varepsilon}_{ist+1}\right) \times \text{std}\left(g_{t+1}\right) \times \varrho\left(\hat{\eta}_{it+1}, g_{t+1}\right)$$

Go to Risk premium