Uncertainty, Imperfect Information and Learning in the International Market

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Introduction

Introduction

- Firms face substantial *uncertainty* and *imperfect information* when entering new markets, e.g., idiosyncratic demand or productivity
- Uncertainty and imperfect information may be resolved by *learning* over firms' life cycles
- This paper provides direct evidence on firm-level (subjective) uncertainty, imperfect information and learning in the international market
    - Use data on firm expectation of future sales
    - New facts regarding firm forecasts and forecast errors

This paper

- We quantify an equilibrium model of imperfect information and learning using unique moments on firm expectation
  - Different implications from different types of uncertainty for market entries, resource allocation and aggregate productivity
  - How existence of imperfect information and learning affects gains from trade in a world with multiple production modes (exporting and FDI)

Related literature

- Uncertainty: Bloom et al. (07), Bloom (09), Handley (14), Handley and Limao (15, 17), Carballo, Handley, and Limao (18), Bloom et al. (16, 18).
- Expectations and forecasts: Coibion and Gorodnichenko (12, 15, 18), Andrade and Le Bihan (13), Bachmann et al. (13, 17), Morikawa (16, 17)
  We use *micro-level* expectation data to show how *firm characteristics* affect firm-level uncertainty and information imperfection.
- Learning and technology choices: Jovanovic (82), Jovanovic and Nyarko (96, 97), Irwin and Klenow (94), Klenow (98), Arkolakis et al. (17)
  We consider the context of international market and emphasize the extensive margins (entry/exit, trade/FDI).
- Learning and information in foreign markets: Fernandes and Tang (14), Timoshenko (15), Conconni et al. (16), Morales and Dickstein (16)
  We measure firms' expectation and provide *direct* evidence for imperfect information and learning.
- Exporter and MNE dynamics: Ruhl and Willis (16), Fitzgerald et al. (16), Gumpert et al. (16), Garetto et al. (16)
  We quantify the role of learning and imperfect information using forecast data + differentiate between *two types of shocks*.

Facts about Forecasts and Forecast Errors

Data

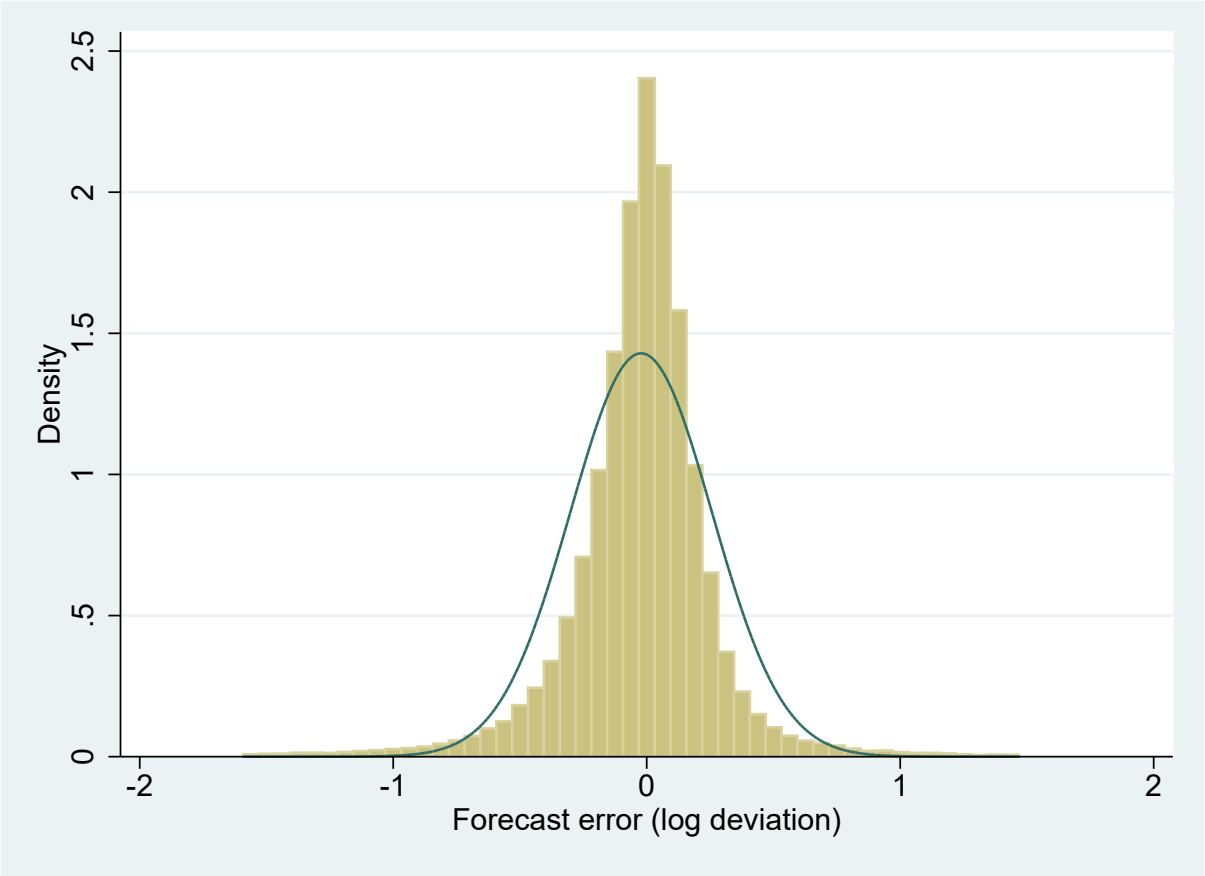
- Japanese firm-level datasets prepared by the Ministry of Economy, Trade and Industry, 1995 - 2014
- Basic Survey of Overseas Business Activities
  - Similar to other MNE datasets such as the BEA survey
  - Multinational affiliates report their "projected sales" for next year: $E_t(R_{t+1})$
- Basic Survey of Japanese Business Structure
  - Japanese *parent firms* with 50+ employees and ¥30 million+ assets
  - export to seven regions
  - Merged with MNE survey using parent firm IDs
- Combined data: $\sim$2300 parents, $\sim$14000 affiliates (firms) each year
- Exclude multinational affiliates in tax haven economies ($13\% - 14\%$ observations).

Definition and descriptive Statistics of FE

- We define forecast error (FE) as

$$FE_t^{\log} = \log\left[R_{t+1} / E_t\left(R_{t+1}\right)\right]$$

- Distribution of $FE_t^{\log}$



Two alternative measures: residual FE and percentage deviation

- Project $FE_{it}^{\log}$ on country-year and industry-year fixed effects

$$\hat{\varepsilon}_{FE^{\log}} = FE_{it}^{\log} - \hat{\delta}_{ct} - \hat{\delta}_{st}$$

- Residual FEs maintain 90% of variation in $FE_{it}^{\log}$
- Percentage deviation: $FE_t^{pct} = R_{t+1} / E_t\left(R_{t+1}\right) - 1$
- Basic facts:
  - Mean of FE is close to zero.
  - Mean of $|FE|$ is about 18% (on average firms under-/over-predict sales by 18%)

Summary statistics of FE

Table 1: Summary Statistics of Forecast Errors

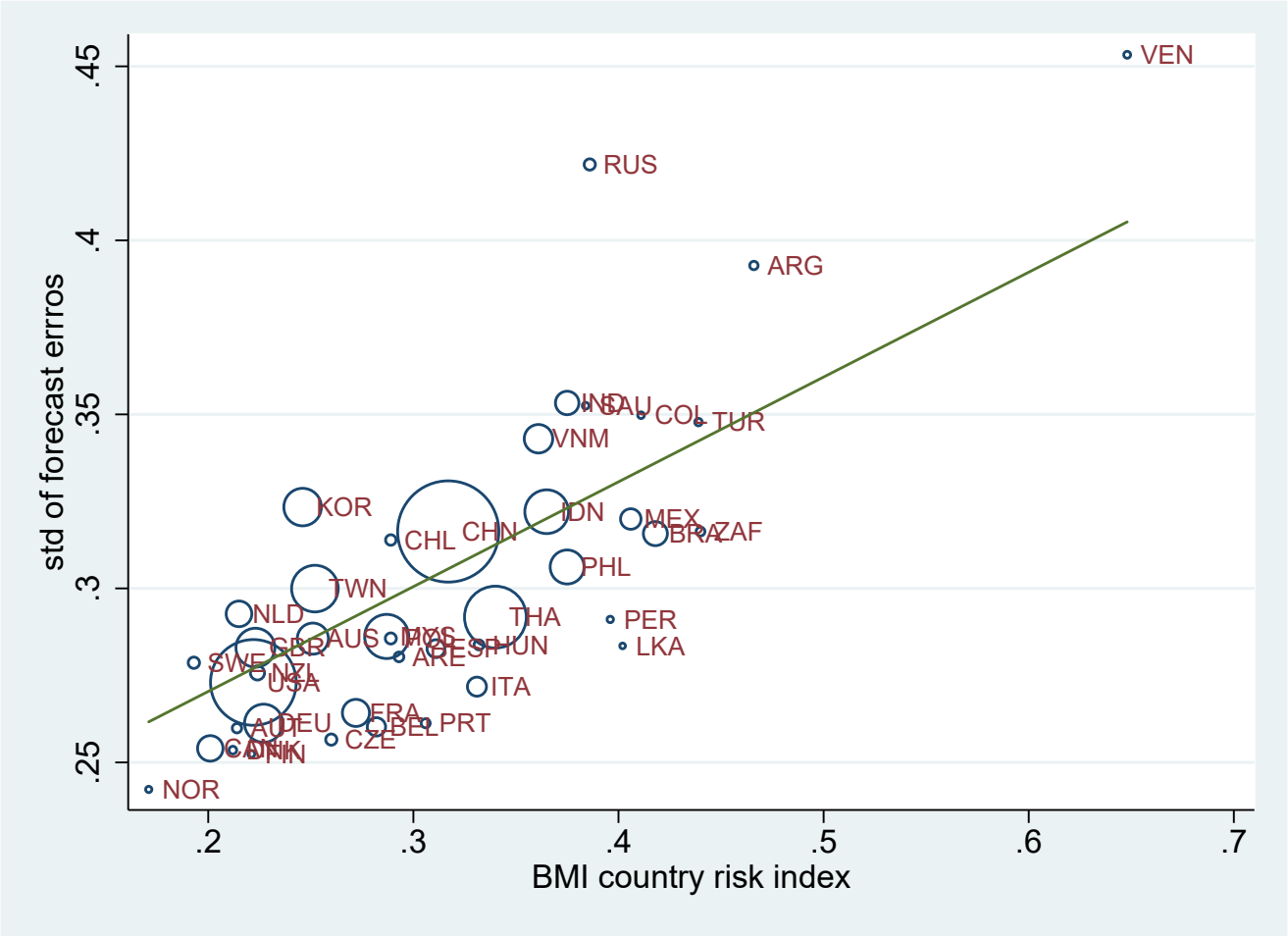
	Obs.	mean	std. dev.	median
FE^{log}	132,056	-0.024	0.300	-0.005
FE^{pct}	132,589	0.017	0.333	-0.006
$\hat{\epsilon}_{FE}$	131,760	-0.000	0.282	0.011
$\lvert FE^{log} \rvert$	132,056	0.200	0.224	0.130
$\lvert FE^{pct} \rvert$	132,589	0.204	0.264	0.130
$\lvert \hat{\epsilon}_{FE} \rvert$	131,760	0.184	0.213	0.116
FE^{log} - Manufacturing	91,580	-0.022	0.279	-0.003
$\lvert FE^{log} \rvert$ - Manufacturing	91,580	0.186	0.209	0.123

FE^{log} is the log deviation of the realized sales from the projected sales, while FE^{pct} is the percentage deviation of the realized sales from the projected sales. The last variable, $|\hat{\epsilon}_{FE^{log}}|$, is the absolute value of the residual forecast error, which we obtain by regressing FE^{log} on a set of industry-year and country-year fixed effects. Top and bottom one percent observations of forecast errors are trimmed.

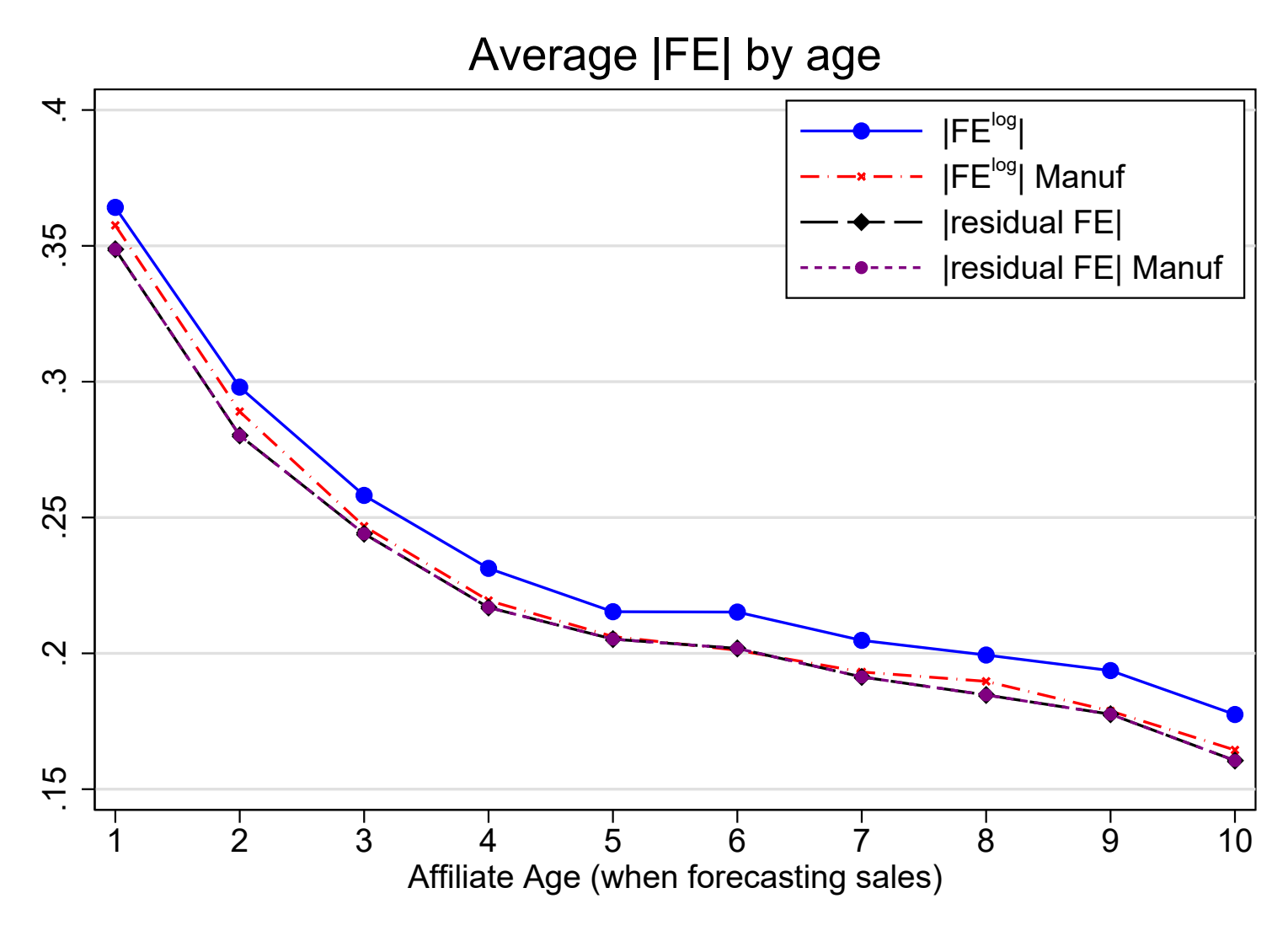
Fact 1: Firm-level uncertainty is positively correlated with aggregate uncertainty

Regression

- $Var(FE)$ and $Var(\hat{\epsilon}_{FE})$ are correlated with country-level risk index (risk of economic crisis and change in political environment).



Fact 2: |FE| declines with firm age



Fact 2: regression of |FE| w.r.t. firm age

Table 2: Age effects on the absolute forecast errors

Dep.Var: $(\lvert FE^{log}_{t,t+1} \rvert)$	(1)	(2)	(3)	(4)	(5)
Sample:		All Affiliates		Survived 7 years	Manufacturing
Age=2	-0.069	-0.065	-0.061	-0.069	-0.057
	(0.007)	(0.007)	(0.008)	(0.011)	(0.009)
Age=3	-0.107	-0.093	-0.080	-0.087	-0.077
	(0.007)	(0.008)	(0.008)	(0.011)	(0.009)
Age=4	-0.132	-0.116	-0.096	-0.098	-0.093
	(0.007)	(0.008)	(0.008)	(0.011)	(0.010)
Age=5	-0.146	-0.125	-0.098	-0.114	-0.092
	(0.007)	(0.007)	(0.008)	(0.011)	(0.010)
Age=6	-0.145	-0.124	-0.093	-0.115	-0.090
	(0.007)	(0.007)	(0.009)	(0.012)	(0.010)
Age=7	-0.156	-0.132	-0.098	-0.127	-0.092
	(0.007)	(0.007)	(0.009)	(0.011)	(0.010)
Age=8	-0.160	-0.134	-0.097	-0.123	-0.090
	(0.007)	(0.008)	(0.009)	(0.012)	(0.010)
log(Parent Domestic Sales)		0.008	0.002	0.011	0.002
		(0.001)	(0.002)	(0.001)	(0.002)
log(Affiliate Sales)		-0.025	-0.058	-0.033	-0.060
		(0.001)	(0.003)	(0.002)	(0.003)
N	131454	117419	111998	17157	83083
R^2	0.097	0.128	0.382	0.148	0.377
Affiliate Fixed Effect	No	No	Yes	No	Yes
Industry Fixed Effect	Yes	Yes	No	Yes	No
Country-year Fixed Effect	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at parent firm level. All coefficients are significant at 1% level, except for the log of parent firm's domestic sales in column 3. The dependent

Fact 3: previous export experience reduces |FE|

- Previous work suggests export experience reduces uncertainty in MP (Conconi et al., 16).
- Data and sample selection:
  - Examine first-time entrants into the host-country/region.
  - Focus on manufacturing parent firms and manufacturing or distributional-oriented affiliates (wholesalers + retailers). ▸ summary

Fact 3: previous export experience reduces $|FE|$

Figure | Robustness

Table 3: Forecast error and previous exporting

Dep.Var: $\lvert FE_{1,2}\rvert$	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	-0.159**			
	(0.065)			
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.151**		
		(0.064)		
Exp $Expe. > 0$			-0.132*	
			(0.070)	
Exp $Expe.$				-0.013**
				(0.006)
Industry FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes
N	553	561	658	658
R^2	0.486	0.499	0.472	0.472

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is affiliates' initial forecast error, which is calculated as the absolute log deviation of the realized sales at age = 2 from the projected sales (predicted by an affiliate at age = 1). We only include affiliates that are first-time entrants into a particular host country. Exporting experience (Exp Expe.) is defined at the continent level for each parent firm. Each column head indicates the different measure of exporting experience used in the regression.

Fact 4: positive autocorrelation of FEs

Table 4: Serial correlation of forecast errors made in two consecutive years

	1	2	3	4	5
corr. $(FE^{\log}_{t-1,t}, FE^{\log}_{t,t+1})$	0.124^{***}	0.121^{***}	0.145^{***}	0.153^{***}	0.146^{***}
Manufacturing firms only?	No	Yes	Yes	Yes	Yes
Type of firms included	all	manufacturing	entrants	survivors	entrants + survivors
N	178140	108135	11013	19968	9799

Notations: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Manufacturing survivors refer to manufacturing affiliates that have survived for at least five years. Manufacturing entrants refer to manufacturing affiliates that entered the destination markets during our sample period.

- Full Information Rational Expectation (FIRE) models imply zero autocorrelation
- Any shock realized up to time t should be incorporated into $E_t Y_{t+1}$, so $Y_{t+1} - E_t Y_{t+1}$ is orthogonal to $Y_t, Y_{t-1}, \ldots$

Fact 4: positive autocorrelation of FEs (Regressions)

Table 5: Regression for the serial correlation of sales forecast errors (including parent firm fixed effects)

	(1) $FE^{pct}_{t,t+1}$	(2) $FE^{\log}_{t,t+1}$	(3) $\hat{\epsilon}_{FE^{log}_{t,t+1}}$	(4) $FE^{pct}_{t,t+1}$	(5) $FE^{\log}_{t,t+1}$	(6) $\hat{\epsilon}_{FE^{log}_{t,t+1}}$
$FE^{pct}_{t-1,t}$	0.0656***			0.0703***		
	(0.00600)			(0.00757)		
$FE^{\log}_{t-1,t}$		0.0642***			0.0631***	
		(0.00526)			(0.00665)	
$\hat{\epsilon}_{FE^{log}_{t-1,t}}$			0.0641***			0.0629***
			(0.00526)			(0.00665)
Type of firms	all	all	all	manufacturing	manufacturing	manufacturing
Parent firm FE Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country-year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N	112766	109775	109765	74353	72792	72789
R^2	0.170	0.191	0.088	0.186	0.209	0.095

FE^{log} is the log deviation of the realized sales from the projected sales, while FE^{pct} is the percentage deviation of the realized sales from the projected sales. The last variable, $\hat{\epsilon}_{FE^{log}}$, is the residual forecast error, which we obtain by regressing FE^{log} on a set of industry-year and country-year fixed effects. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Top and bottom one percent observations of forecast errors

Fact 4: age and positive autocorrelation of FEs

export experience

Table 6: Age effects on the correlation of forecast errors (all firms)

Dep.Var: $1(Sign(FE^{log}_{i,t}) = Sign(FE^{log}_{i,t-1}))$	(1)	(2)	(3)	(4)
Age=3	-0.0541**	-0.0302		
	(0.0312)	(0.0322)		
Age=4	-0.0247	-0.0177		
	(0.0324)	(0.0349)		
Age=5	-0.0593**	-0.0553		
	(0.0326)	(0.0348)		
Age=6	-0.0530	-0.0505		
	(0.0338)	(0.0357)		
Age=7	-0.0674***	-0.0426		
	(0.0343)	(0.0363)		
Age=8	-0.0982***	-0.0800***		
	(0.0345)	(0.0371)		
Age=9	-0.0847***	-0.0661**		
	(0.0349)	(0.0372)		
log(Affiliate Age)			-0.0578**	-0.0459
			(0.0302)	(0.0322)
log(Affiliate Sales)		-0.00525		-0.00597
		(0.00881)		(0.00884)
log(Parent Domestic Sales)		0.0127		0.0126
		(0.0117)		(0.0118)
N	92313	82861	92313	82861
R^2	0.193	0.201	0.193	0.201
Subsidiary FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable equals 1 if forecast errors made in two consecutive years have the same sign

Fact 5: Both lagged forecast and sales predict current sales

Table 7: Both Current Sales and Forecasts Predict Future Sales

Dep.Var: $\log(R_t)$	(1)	(2)	(3)	(4)	(5)
Sample:	All	All	All	Manufacturing	Manu. & Survivors
$\log(E_{t-1}(R_t))$	0.968***	0.716***	0.660***	0.725***	0.777***
	(0.002)	(0.011)	(0.013)	(0.012)	(0.018)
$\log(R_{t-1})$		0.254***	0.251***	0.246***	0.186***
		(0.010)	(0.016)	(0.011)	(0.016)
$\log(R_{t-2})$			0.072***		
			(0.008)		
Industry-year FE	Yes	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes	Yes
N	134110	132636	111447	91716	13198
R^2	0.939	0.947	0.955	0.950	0.938

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is affiliates' log sales in period t. Regressors are affiliates' log forecasts about R_t at time $t-1$ and lagged log sales. Columns 1-3 include all firms. Column 4 only includes the manufacturing (or wholesale or retail) affiliates whose parent firms are in manufacturing. Column 5 further restricts to affiliates that have survived at least 7 years (from age one to age seven) in our sample.

◂ Robustness: domestic firms

A Dynamic Industry Equilibrium Model

Major elements of the model

1. Dynamic choices of exporting and MP: variable v.s. entry costs
2. Learning (Bayesian updating) about foreign demand as in Arkolakis et al. (2017)
3. Information rigidity similar to Mankiw and Reis (2002): every period, $1-\alpha$ fraction of firms switch from "uninformed" to "informed" and start updating

- Both 2 and 3 generate reduction in $Var(FE)$ over firms' life cycles (Fact 2)
- 1 + 2 rationalize "learning from exporting" (Fact 3)
- 3 explains positive autocorrelation in FEs (Fact 4)
- 2 + 3 explain that both forecast and lagged sales predict current sales (Fact 5)

Setup: Consumer Demand

- Time is discrete: $t = 1, 2, \ldots$
- Consumer demand: monopolistic competition

$$Q_{jp,t} = \left(\int_{\omega \in \Sigma_{jp,t}} e^{\frac{a_t(\omega)}{\sigma}} q_t(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}.$$

- Firm-specific demand shifter $a_t(\omega)$ follows

$$a_t(\omega) = \theta(\omega) + \varepsilon_t(\omega), \ \varepsilon_t(\omega) \overset{i.i.d.}{\sim} N\left(0, \sigma_\varepsilon^2\right)$$

- $\theta(\omega)$ is drawn from $N\left(\bar{\theta}, \sigma_\theta^2\right)$. Firms learn about θ by observing a_t

Setup: Firms

- Japanese firms can serve foreign market via export or MP
  - Export: lower entry cost, but higher variable cost
  - MP: higher entry cost, but lower variable cost.
- Costs:
  - Trade costs: (τ, f_x, f_x^e); MP costs: $(f_m, f_m^e(\omega))$
  - $f_m^e(\omega)$ is drawn from $logN(\mu_{f_m^e}, \sigma^2_{f_m^e})$. ▸ Evidence
- Firm produces only using labor $q_t = l_t$.

Timing

1. Exogenous mass 1 of entrants draw f_m^e and θ, but θ is unknown
2. Entrants and incumbents:
   - 2.1 exogenous exit
   - 2.2 exit, exporting or MP
   - 2.3 choose employment l_t (thus q_t)
   - 2.4 observe a_t and set price p_t to clear the market
   - 2.5 "uninformed" firms switch to "informed" firms (prob. $1 - \alpha$)
   - 2.6 informed firms update belief about θ

Belief updating (informed firms)

Denote signal-to-noise ratio as $\lambda \equiv \sigma_\theta^2 / \sigma_\varepsilon^2$

After the firm observes $a_1, a_2, \ldots, a_{n-1}$, the posterior about θ of an informed firm is normal with mean μ_{n-1} and variance σ_{n-1}^2

$$\mu_{n-1} = \frac{1}{1+(n-1)\lambda}\bar{\theta} + \frac{(n-1)\lambda}{1+(n-1)\lambda}\bar{a}_{n-1};$$

$$\sigma_{n-1}^2 = \frac{\sigma_\varepsilon^2 \lambda}{1+(n-1)\lambda}.$$

where

$$\bar{a}_{n-1} \equiv \frac{1}{n-1}\sum_{i=1}^{n-1} a_i \text{ for } n \geq 2; \bar{a}_0 \equiv \bar{\theta}.$$

State Variables and Equilibrium

- Firms' state variables are: f_m^e, n, $\bar{a}_{n-1}$, service mode $o \in \{x, m\}$ and informed or not $in = 0, 1$ ▸ value functions
- Partial equilibrium in the sense that following variables are fixed and exogenous:
  - wages in Japan and the foreign country
  - Foreign aggregate expenditure
  - mass of potential entrants

Implications on Forecast Errors

- Firms cannot perfectly foresee their sales because
  - they are uncertain about θ since they only observe $a_t = \theta + \varepsilon_t$
  - transitory shock ε_t generates uncertainty
  - some firms are uninformed
- Match the four facts
  1. $Var(FE)$ declines with age and export experience as firms gradually learn and more firms become informed over time
  2. Positive autocorrelation of FEs is caused by uninformed firms ▸ Details
  3. Co-existence of informed and uninformed firms: both past sales and sales forecasts predict future sales ▸ Details

Intuition for Calibration of σ_ε, σ_θ and α

- For old firms, almost all are informed and posterior $N(\mu_{n-1}, \sigma^2_{n-1})$ converges to $\theta \rightarrow$ almost all FEs come from ε:

$$Var\left(FE^{\log}_{n-1,n}\right) = Var\left(\frac{\theta - \mu_{n-1}}{\sigma}\right) + \frac{\sigma^2_\varepsilon}{\sigma^2} \rightarrow \frac{\sigma^2_\varepsilon}{\sigma^2}.$$

- For uninformed firms or firms without any experience, both θ and ε generate FE:

$$Var\left(FE^{\log}_{0,1}\right) = Var\left(\frac{\theta - \mu_0}{\sigma}\right) + \frac{\sigma^2_\varepsilon}{\sigma^2} = \frac{\sigma^2_\theta + \sigma^2_\varepsilon}{\sigma^2}$$

- For firms of age t, only α^t fraction of uninformed firms contribute to the autocorrelation of FEs

$$cov(FE^{\log}_{t-1,t}, FE^{\log}_{t,t+1}) = \alpha^t cov\left(\frac{\varepsilon_t + \theta - \bar{\theta}}{\sigma}, \frac{\varepsilon_{t+1} + \theta - \bar{\theta}}{\sigma}\right) = \frac{\alpha^t \sigma^2_\theta}{\sigma^2}.$$

Quantitative Analysis

Calibration

- Normalization
  - wage in the foreign country $w^* = 1$
  - wage in Japan $w = 1$
  - total expenditure on Japanese goods $Y = 1$
  - mean of θ is normalized to zero.
  - mass of entrants J=1
  - export entry cost $f_X^e = 0$ (abstract from domestic production)
- parameters calibrated without solving the model
- parameters calibrated by solving the model and matching moments

Calibration - without solving model

Parameters	Description	Value	Source
σ	Elasticity of substitution between Japanese goods	4	Bernard et al. (2003)
δ	Armington elasticity between goods from different countries	2	
β	Discount factor	0.96	4% real interest rate
η	Exogenous death rate	0.03	Average exit rates of multinational affiliates
f_m	FDI per-period fixed costs	0	Flat profile of affilates' exit rate over their life cycles ▸ Age effect on Exit Rates

Calibration - without solving model

- Given that inexperienced MNEs are not selected based on θ when $f_m = 0$, we can map $\sigma_\theta, \sigma_\varepsilon, \alpha$ to $Var(FE_{1,2})$, $Var(FE_\infty)$ and $Cov(FE_{1,2}, FE_{2,3})$ without solving the model

Table 8: Parameters related to forecast errors and moments

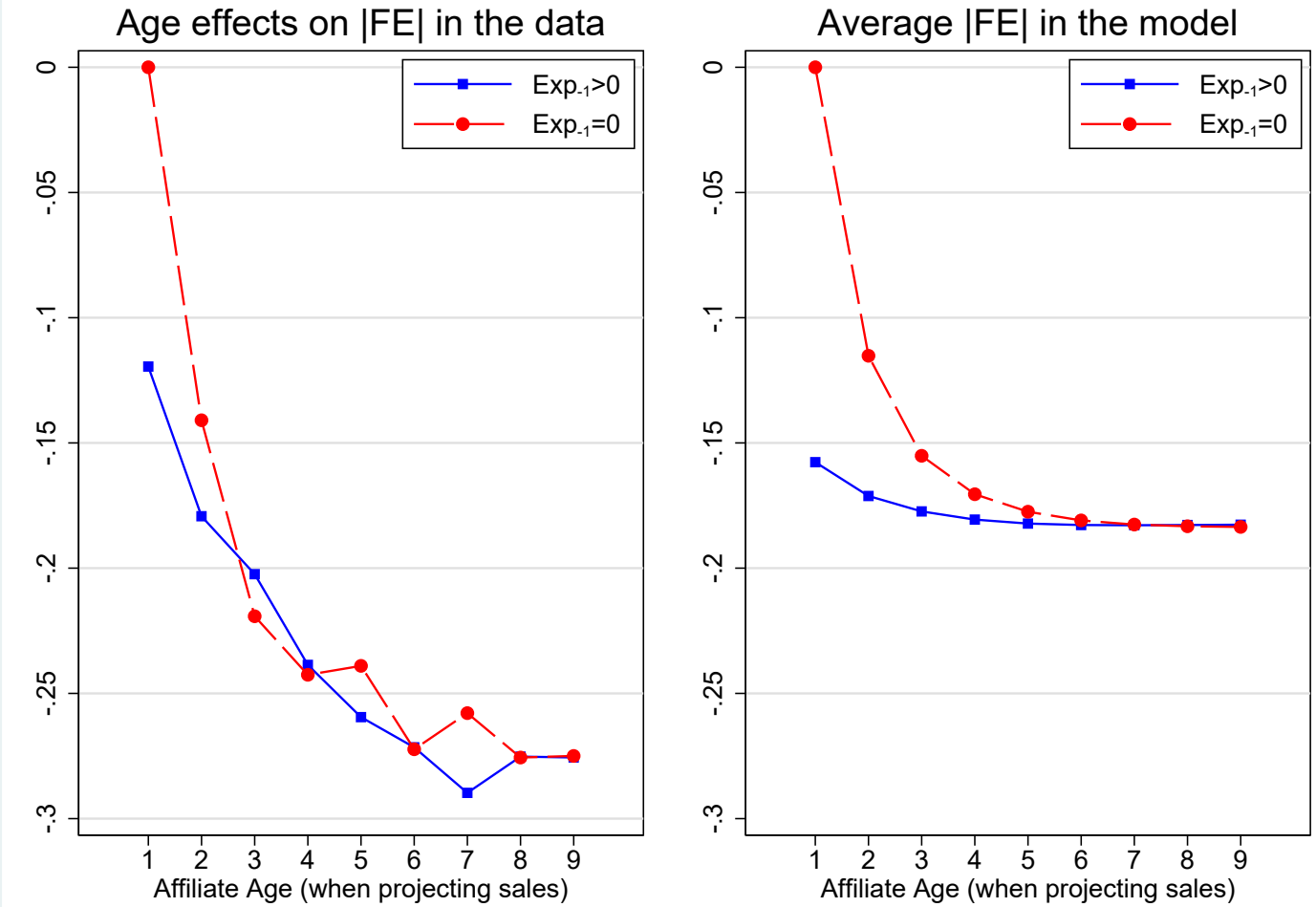
Parameters	Value	Description	Moments	Data	Model
σ_θ	2.05	Std of time-invariant shock	Var. of FE at age 1	0.48	0.48
σ_ϵ	0.90	Std of transitory shock	Var. of FE at age 10	0.24	0.24
α	0.21	prob of awaking	Cov of $FE_{1,2}$ and $FE_{2,3}$	0.034	0.034

Calibration - solve model and match moments

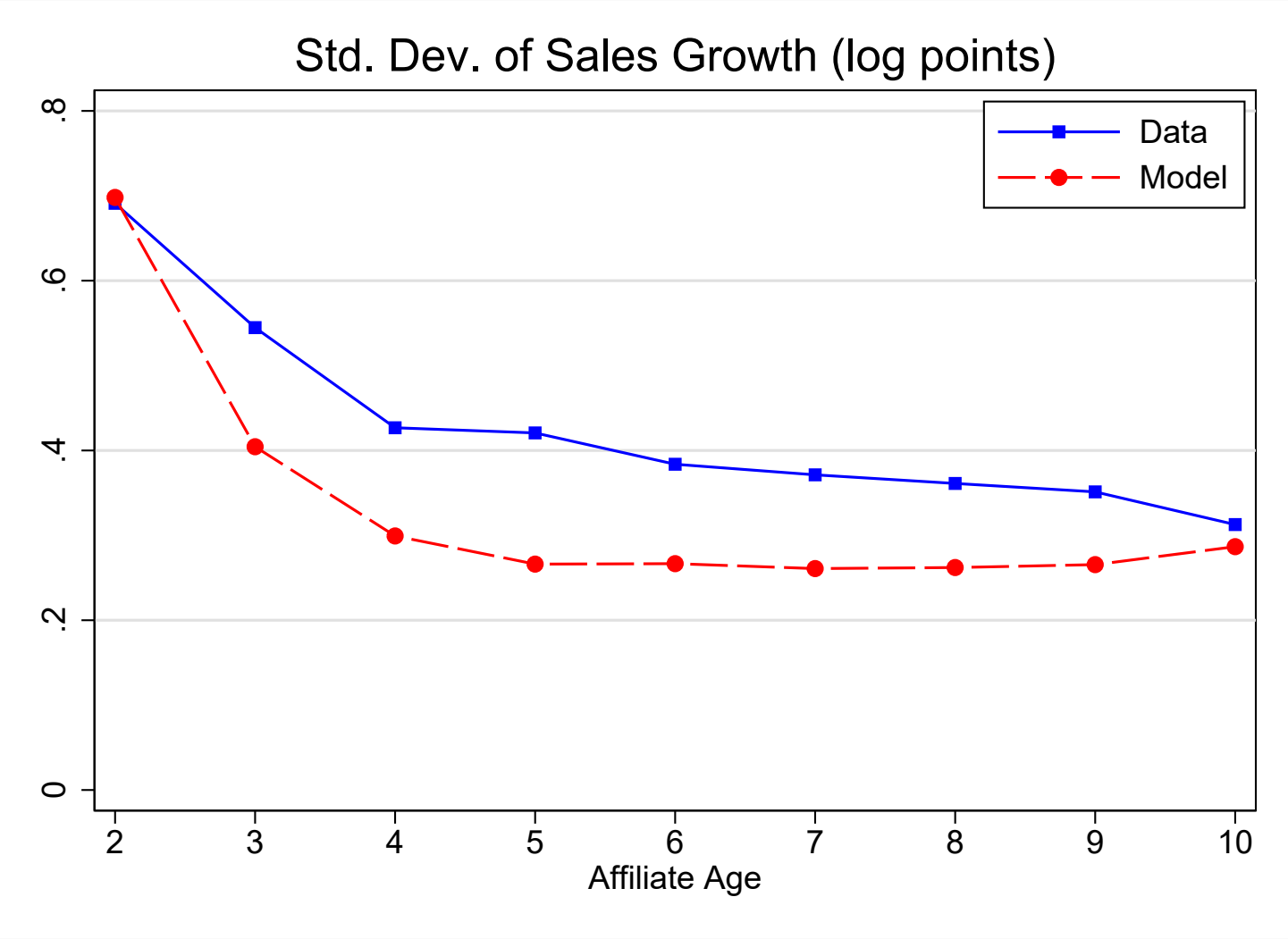
Table 9: Parameters calibrated by solving the model and matching moments

Parameters	Value	Description	Moments	Data	Model
f_x	0.0053	export fixed cost	average exit rate of exporters	0.10	0.11
$\mu_{f_m^e}$	1.59	mean of log FDI entry cost	fraction of exporters among active firms	0.70	0.69
$\sigma_{f_m^e}$	2.45	Std of log FDI entry cost	fraction of experienced MNEs at age 1	0.73	0.75
τ	1.46	iceberg trade cost	Exporter sales share	0.21	0.21

Untargeted moments: $|FE|$ for experienced and non-experienced MNEs



Untargeted moments: decline of volatility of sales growth rate over life cycle



Other untargeted moments

- Growth rates of exporters ▸ Details
- Exit rates of exporters ▸ Details
- Regressing $FE_{t,t+1}$ on $FE_{t-1,t}$ ▸ Details
- Regressing $\log(R_{t+1})$ on $\log(E_t R_{t+1})$ and $\log(R_t)$ ▸ Details

Overview of counterfactuals

- Interaction between imperfect information and gains from trade
- Change level of "uncertainty": σ_ε and σ_θ.

Interaction between imperfect information and gains from trade

- Exporting generates information value under imperfect information (i.e., extensive margins)
- Two trade regimes: trade only or trade + MP
  - GT: gain from reducing τ to 1 for trade + MP
  - GT^*: gain from reducing τ for trade only
- Complementarity between gain from reducing trade costs and imperfect information
  - Gain from trade is always larger in world with imperfect information
  - Difference is bigger in trade + MP regime (multiple production modes) than in trade only regime (single production mode)

Table 10: Complementarity between Trade and MP

Welfare Measure	Labor Productivity Q/L		
	GT	GT^*	GT/GT^*
Imperfect Information	1.17	1.47	0.79
Perfect Information	1.08	1.46	0.74

Variation of parameters across countries/regions

- We only have enough observations for Asia (excluding China), China, North America and Europe.

Table 11: Moments and parameters for different regions

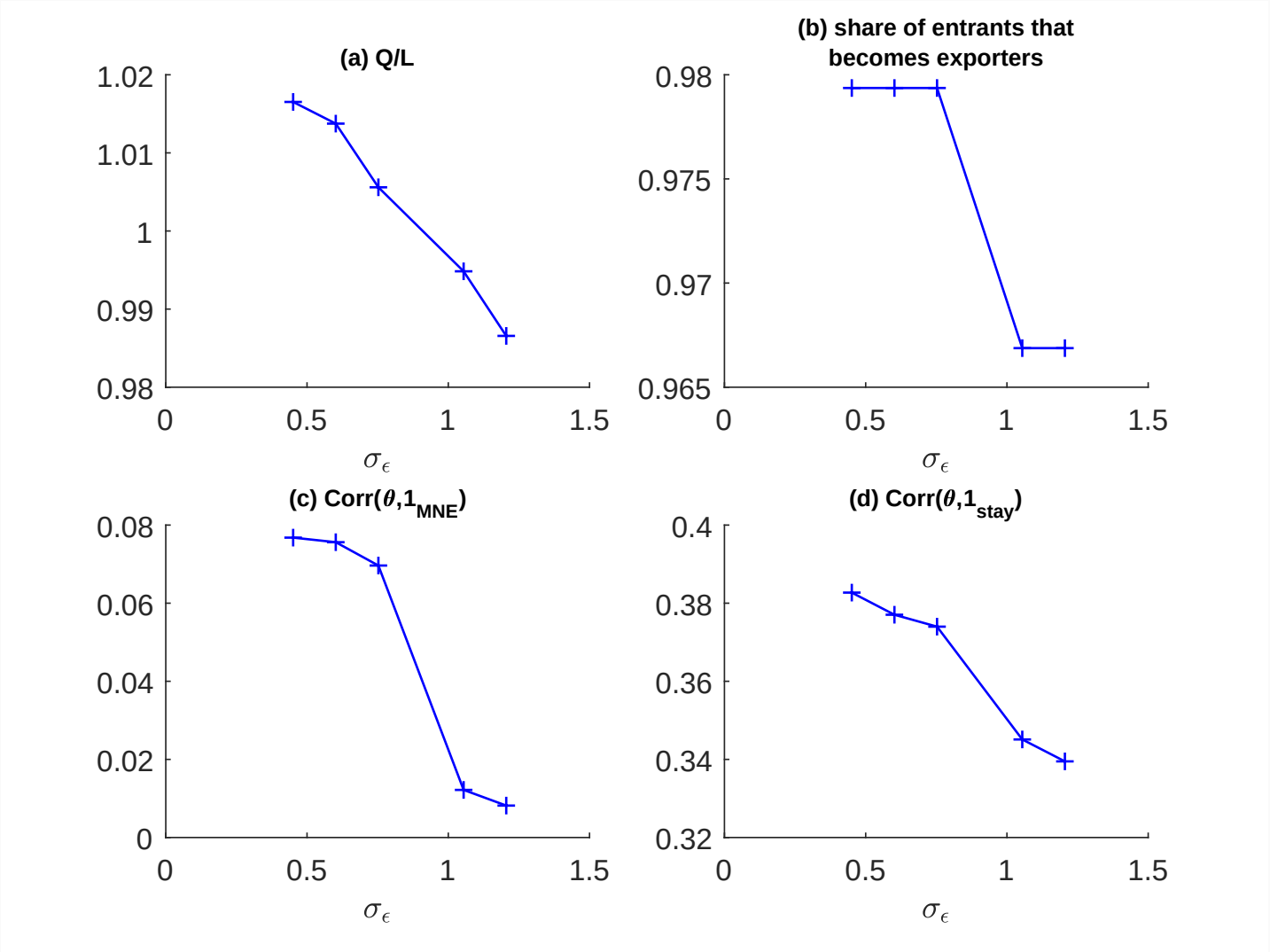
Region	Asia (non-China)	China	North America	Europe
Moments				
Var of $FE_{1,2}$	0.48	0.62	0.45	0.42
Var of FE_{10+}	0.24	0.28	0.23	0.26
Parameters				
σ_θ	2.09	2.78	1.91	1.60
σ_ϵ	0.91	1.08	0.87	0.98

Note: As before, we only use non-experienced affiliates when calculating moments related to the variance and auto-covariance of FEs for the above four regions.

More exploratiosn: ▸ Aggregate Risk ▸ EPU

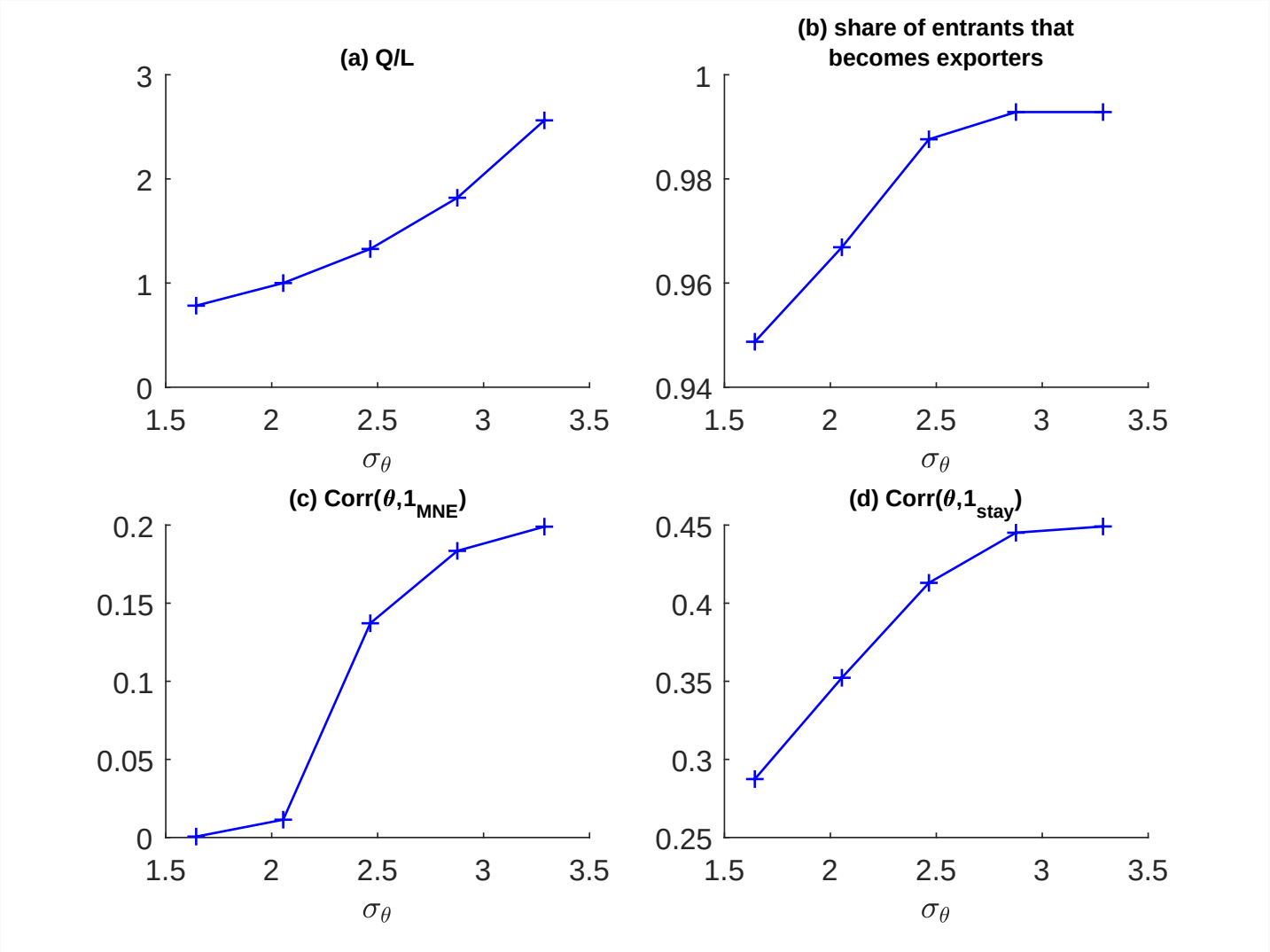
Change σ_ε

We increase σ_ε, but reduce $\bar{\theta}$ to keep $E\left(e^{\frac{\theta+\varepsilon}{\sigma}}\right)$ constant.



Change σ_θ

We increase σ_θ, but reduce $\bar{\theta}$ to keep $E(e^{\frac{\theta+\varepsilon}{\sigma}})$ constant.



Changing σ_ε and σ_θ: Summary

- Increasing σ_ε
  - lower signal-to-noise ratio $\rightarrow$ less effective learning
  - Less information before entering MP
  - Fundamental demand less correlated with MP or staying
- Increasing σ_θ
  - higher signal-to-noise ratio $\rightarrow$ more effective learning
  - More information before entering MP
  - Fundamental demand more correlated with MP or staying
- Both are sources of "uncertainty", but have very different effects

Conclusions

- New evidence on firm-level uncertainty, imperfect information and learning in international market
- A simple quantifiable model to capture the dynamics of FEs
- Quantify how information imperfection affects productivity gains from trade in world with multiple production modes
- The effects of the two sources of uncertainty $(\sigma_\varepsilon, \sigma_\theta)$ are different

Appendix: Empirical work

Fact 1: |FE| and aggregate risk/volatility (within-HQs and across destination markets)

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Table 12: Affiliates' uncertainty and country risk index

	(1) $\lvert FE^{log}\rvert$	(2) $\lvert FE^{pct}\rvert$	(3) $\lvert\hat{\epsilon}_{FE}\rvert$	(4) $\lvert FE^{log}\rvert$	(5) $\lvert FE^{pct}\rvert$	(6) $\lvert\hat{\epsilon}_{FE}\rvert$
Country risk index	0.275***	0.261***	0.264***			
	(0.042)	(0.041)	(0.049)			
$\sigma(\Delta log(GDP))$				1.061**	1.081***	0.988**
				(0.405)	(0.377)	(0.431)
N	130601	131105	130342	130522	131026	130276
R^2	0.149	0.151	0.140	0.146	0.150	0.137
Industry-year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Parent Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Mean of X	0.291			0.027		
Std. Dev. of X	0.062			0.010		

Standard errors are two-way clustered at country and parent firm level, * 0.10 ** 0.05 *** 0.01. Each column head lists the dependent variable of the regressions. $|FE^{log}|$ is the absolute log deviation of the realized sales from the projected sales; $|FE^{pct}|$ is the absolute percentage deviation of the realized sales from the projected sales; $|\hat{\epsilon}_{FE}|$ is the absolute value of the residual forecast error, which we obtain by regressing FE^{log} on a

Distribution of Export Experience before Affiliate Entry

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Table 13: Years of exporting experience before affiliate entry

	Frequency	Percent
0	187	28.4
1	48	7.3
2	44	6.7
3	46	7.0
4	35	5.3
5	43	6.5
6	35	5.3
7	28	4.3
8	30	4.6
9	19	2.9
10	38	5.8
11	32	4.9
12	18	2.7
13	22	3.3
14	15	2.3
15	18	2.7
Total	658	100.0

Only first-time entrant affiliates (into a country) that report their sales at age $= 2$, project sales at age $= 1$ and have nonmissing exporting experience are included in the sample.

Fact 3: plotting age coefficients

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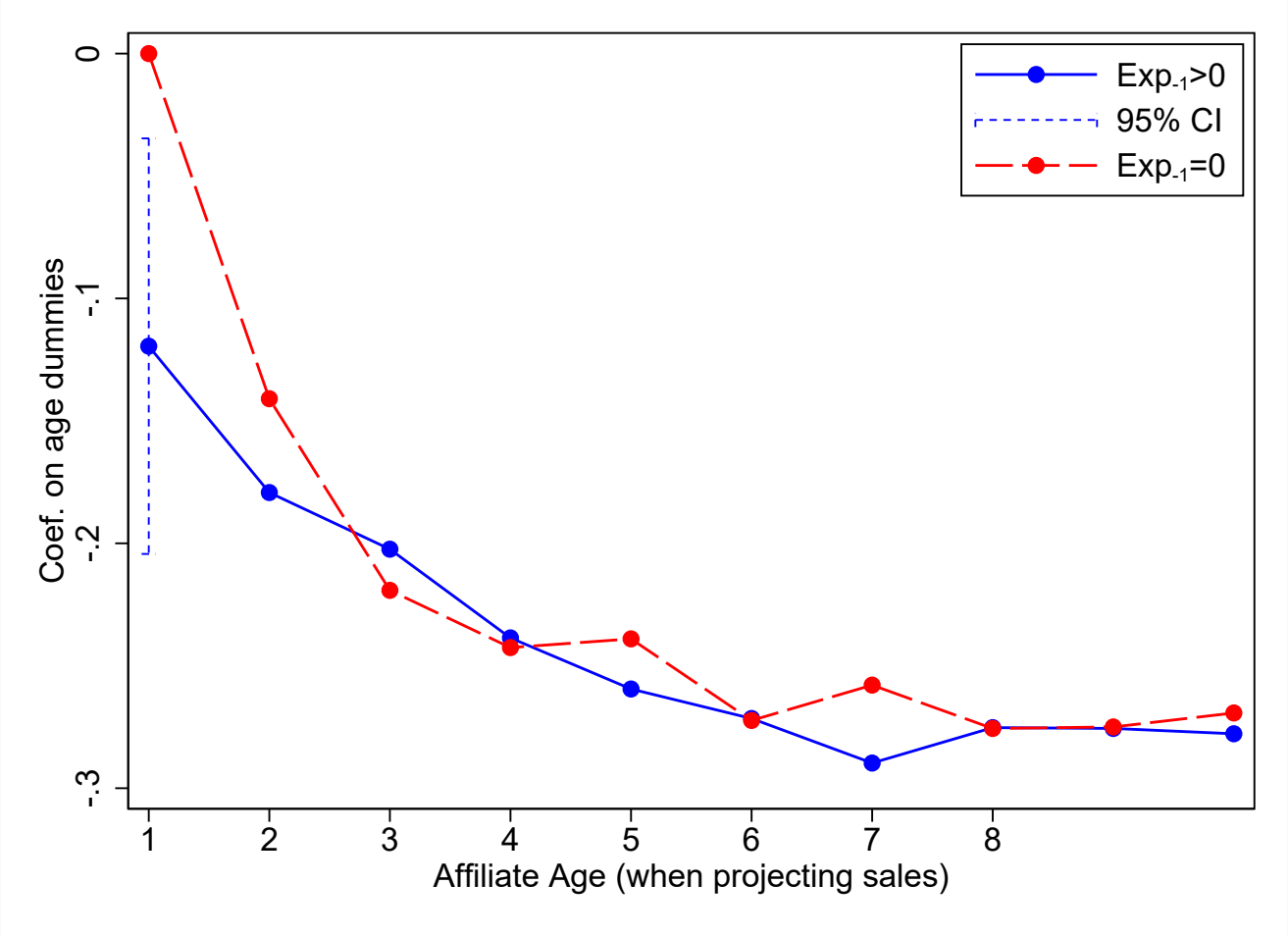

Fact 3: robustness

Back

- First-time entrants into regions Results
- Controlling for parent firm and affiliate size Results
- Horizontal FDI only: exclude affiliates that sell more than 1/3 of its output to Japan Results
- Refine definition of export experience: exclude intra-firm exports to the same region Results
- Use $|\hat{\epsilon}_{FE}|$ instead Results

Robustness: control for firm size

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Table 14: Forecast error and previous exporting - control firm size

	(1)	(2)	(3)	(4)	(5)	(6)
$Exp_{-1} > 0$	-0.151**	-0.115*				
	(0.063)	(0.062)				
$Exp_{-1} > 0$ or $Exp_{-2} > 0$			-0.147**	-0.121*		
			(0.063)	(0.064)		
Exp $Expe. > 0$					-0.113*	-0.077
					(0.065)	(0.063)
log(Parent Employment)	0.017		0.021		0.009	
	(0.023)		(0.022)		(0.021)	
log(Affiliate Employment)	-0.031		-0.020		-0.045**	
	(0.020)		(0.018)		(0.018)	
log(Parent Domestic Sales)		0.018		0.021		0.018
		(0.017)		(0.016)		(0.016)
log(Affiliate Sales)		-0.054***		-0.052***		-0.058***
		(0.014)		(0.013)		(0.014)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	549	534	557	543	654	625
R^2	0.493	0.535	0.503	0.541	0.485	0.532

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent

Robustness: exclude vertical FDI and affiliated export

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Table 15: Forecast error and previous exporting - exclude vertical FDI and affiliated export

	Exclude vertical FDI			Exclude affiliated export		
Dep.Var: $\lvert FE_{1,2} \rvert$	(1)	(2)	(3)	(4)	(5)	(6)
$Exp_{-1} > 0$	-0.166**			-0.099		
	(0.073)			(0.067)		
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.155**			-0.141**	
		(0.072)			(0.067)	
Exp $Expe. > 0$			-0.159**			-0.114
			(0.078)			(0.071)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	456	464	551	441	446	551
R^2	0.542	0.549	0.529	0.545	0.554	0.524

a Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is the absolute log deviation of the realized sales at age = 2 from the projected sales (predicted by an affiliate at age = 1). We only include affiliates that are first-time entrants into a particular continent. Exporting experience (Exp Expe.) is defined at the continent level for each parent firm.

b In columns 1-3, we exclude affiliates whose sales share back to Japan is larger

Robustness: first-time entrants into regions

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Table 16: Forecast error and previous exporting (first entrants into continents)

Dep.Var: $\lvert FE_{1,2} \rvert$	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	-0.303*			
	(0.168)			
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.175		
		(0.173)		
Exp $Expe. > 0$			-0.226	
			(0.169)	
Exp $Expe.$				-0.034*
				(0.020)
Industry FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes
N	153	152	185	185
R^2	0.601	0.589	0.592	0.607

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is affiliates' initial forecast error, which is calculated as the absolute log deviation of the realized sales at age = 2 from the projected sales (predicted by an affiliate at age = 1). We only include affiliates that are first-time entrants into a particular continent. Exporting experience (Exp Expe.) is defined at the continent level for each parent firm.

Robustness: residual forecast error

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Table 17: Forecast error and previous exporting

Dep.Var: $\lvert\hat{\epsilon}_{FE,(1,2)}\rvert$	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	-0.139**			
	(0.066)			
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.142**		
		(0.064)		
Exp $Expe. > 0$			-0.121*	
			(0.070)	
Exp $Expe.$				-0.013**
				(0.006)
Industry FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes
N	552	560	657	657
R^2	0.462	0.475	0.446	0.447

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is affiliates' initial residual forecast error. We only include affiliates that are first-time entrants into a particular host country. Exporting experience (Exp Expe.) is defined at the continent level for each parent firm. Each column head indicates the different measure of exporting experience used in the regression.

Fact 4: export experience and correlation of FEs

Table 18: Export experience and the correlation of forecast errors

Dep.Var: $1(Sign(FE^{log}_{i,t}) = Sign(FE^{log}_{i,t-1}))$	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	-0.397**		-0.432**	
	(0.200)		(0.204)	
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.525**		-0.592***
		(0.203)		(0.209)
log(Parent Domestic Sales)			0.0738*	0.0710*
			(0.0376)	(0.0374)
log(Affiliate Sales)			-0.0282	-0.0272
			(0.0414)	(0.0407)
N	359	359	346	352
R^2	0.340	0.348	0.352	0.360
Industry FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable equals 1 if forecast errors made in two consecutive years have the same sign and -1 otherwise. Forecast error is calculated as the log deviation of the realized sales from the projected sales.

▸ Go back

Fact 5: robustness (Domestic Firms)

Table 19: Forecasted sale and profits and realized sales and profits

	Dependent Variable: $log(profits)_t$		Dependent Variable: $log(sales)_t$	
Sample:	all	all	all	all
$log(profitsforecast)_{t-1,t}$	0.469^{***}	0.389^{***}		
	(0.00794)	(0.00902)		
$log(profits)_{t-1}$	0.00587	0.00319		
	(0.00688)	(0.00649)		
$log(profits)_{t-2}$		0.160^{***}		
		(0.00765)		
$log(salesforecast)_{t-1,t}$			0.714^{***}	0.565^{***}
			(0.0135)	(0.0185)
$log(sales)_{t-1}$			0.100^{***}	0.0720^{***}
			(0.0147)	(0.0124)
$log(ales)_{t-2}$				0.204^{***}
				(0.0169)
N	60276	56152	84518	83343
R^2	0.896	0.904	0.991	0.992
Firm Fixed Effect	Yes	Yes	Yes	Yes
Semi-year Fixed Effect	Yes	Yes	Yes	Yes

Standard errors are clustered at firm level, * 0.10 ** 0.05 *** 0.01. Forecasts are made before current semi-year starts.

◂ Back

Export experience and initial size/productivity

Table 20: Exporting Experience and Firm Size/Productivity

Dependent Var:	log(Affiliate Sales)		log(Sales/Emp)	
	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	0.297		0.413*	
	(0.284)		(0.223)	
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		0.600**		0.592**
		(0.279)		(0.242)
Industry FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes
N	811	808	778	778
R^2	0.572	0.577	0.648	0.652

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is affiliates' sales or labor productivity at age 1. We only include affiliates that are first-time entrants into a particular host country. Exporting experience is defined at the continent level for each parent firm.

▸ Go back

Export experience, age and exit rates

Go back

Table 21: Export Experience, Age and Affiliate Exits

Dep.Var: Exit Dummy	Age = 1		All Ages	
	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	0.006		-0.007	
	(0.005)		(0.005)	
$Exp_{-1} > 0 \mid Exp_{-2} > 0$		0.006		-0.005
		(0.005)		(0.006)
Age $\times (Exp_{-1} = 0)$			0.000	
			(0.001)	
Age $\times (Exp_{-1} > 0)$			-0.000	
			(0.000)	
Age $\times (Exp_{-1} = 0 \,\&\, Exp_{-2} = 0)$				0.000
				(0.001)
Age $\times (Exp_{-1} > 0 \mid Exp_{-2} > 0)$				-0.000
				(0.000)
N	1285	1288	19249	18821
R^2	0.226	0.228	0.047	0.047
Industry FE	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. Dependent variable is a dummy variable, which equals one when the affiliate exits next year. We only include affiliates that are first-time entrants into a particular host country. Exporting

Aggregate risk and σ_ε^2

Table 22: Firm-level Uncertainty and Country-level Risks

	(1) $\lvert FE^{log} \rvert$	(2) $\lvert FE^{pct} \rvert$	(3) $\lvert \hat{\epsilon}_{FE^{log}} \rvert$
Country risk index	0.0702**	0.0547**	0.0846**
	(0.0302)	(0.0272)	(0.0357)
log(*sales*)	-0.0209***	-0.0197***	-0.0162***
	(0.00113)	(0.00105)	(0.00102)
N	65280	65224	65379
R^2	0.198	0.175	0.202
Firm Age	≥ 8	≥ 8	≥ 8
Industry-year Fixed Effect	Yes	Yes	Yes
Parent Fixed Effect	Yes	Yes	Yes
Age Fixed Effect	Yes	Yes	Yes

Standard errors are clustered at the country level, * 0.10 ** 0.05 *** 0.01.

▸ Go back

EPU and σ_ε^2

- EPU positively affects firm-level volatility (σ_ε^2):
  - Macro stabilization policies and rule-based (i.e., non-discretionary) policies at aggregate level are positively related to volatility of firm-level demand and supply conditions.

Table 23: Correlation between EPU and firm-level volatility

	FE^{pct}	FE^{log}	$\hat{\epsilon}_{FE^{log}}$
Economic Policy Uncertainty Index	0.2910	0.1740	0.1873
Type of Firms	all	all	all
obs.	19	19	19

▸ Go back

Appendix: theory

Informed Exporter's value function (prior to choosing service mode)

$$V_{in}\left(x, f_m^e, n, \bar{a}_{n-1}\right)$$

$$= \max_{o' \in \{x,m,exit\}} \left\{ \begin{array}{c} E\pi_{x,t} + \beta(1-\eta) EV_{in}\left(x, f_m^e, n+1, \bar{a}_n\right), \\ E\pi_{m,t} - w f_m^e + \beta(1-\eta) EV_{in}\left(m, f_m^e, n+1, \bar{a}_n\right), \\ V_{exit} \end{array} \right\},$$

- MP costs are paid using domestic labor.
- $E\pi_{x,t}$ and $E\pi_{m,t}$ are expected profits from exporting and MP.
- Expectations are based on information available at the beginning of period t (equivalently to the end of period $t-1$).
- Informed MNE's value functions can be defined similarly.

◂ Back

Uninformed Exporter's value function (prior to choosing service mode)

$$
\begin{aligned}
& V_{un}\left(x, f_m^e, 1, \bar{a}_0\right) \\
= & \max_{o' \in \{x,m,exit\}} \left\{ \begin{array}{c} E\pi_{x,t} + \beta(1-\eta)\alpha EV_{un}\left(x, f_m^e, 1, \bar{a}_0\right) \\ +\beta(1-\eta)(1-\alpha)EV_{in}\left(x, f_m^e, 2, \bar{a}_1\right), \\ E\pi_{m,t} - wf_m^e + \beta(1-\eta)\alpha EV_{un}\left(m, f_m^e, 1, \bar{a}_0\right) \\ +\beta(1-\eta)(1-\alpha)EV_{in}\left(m, f_m^e, 2, \bar{a}_1\right), \\ V_{exit} \end{array} \right\},
\end{aligned}
$$

- Uninformed firms' posterior belief is the same as entrants, so $n = 1$
- Uninformed MNE's value functions can be defined similarly.

◂ Back

Entrant's value function (prior to choosing service mode):

$$
\begin{aligned}
& V_{un}\left(ent, f_m^e, 1, a_0\right) \\
= & \max_{o' \in \{x,m,exit\}} \left\{ \begin{array}{c} E\pi_{x,t} + \beta(1-\eta)\alpha EV_{un}\left(x, f_m^e, 1, \bar{a}_0\right) \\ +\beta(1-\eta)(1-\alpha) EV_{in}\left(x, f_m^e, 2, \bar{a}_1\right) - wf_x^e, \\ E\pi_{m,t} + \beta(1-\eta)\alpha EV_{un}\left(m, f_m^e, 1, \bar{a}_0\right) \\ +\beta(1-\eta)(1-\alpha) EV_{in}\left(m, f_m^e, 2, \bar{a}_1\right)) - wf_m^e, \\ V_{exit} \end{array} \right\}.
\end{aligned}
$$

◂ Back

Intuition for autocorrelation in FEs

- We have seen that "sleeping firms" generates positive autocorrelation
- Informed firms do not generate positive autocorrelation
  - Posterior about θ formed using Bayes' rule minimizes mean squared error and is best (linear) predictor
  - Therefore, $FE_{t,t+1}$ is uncorrelated with any variable realized before $t+1$ (including $FE_{t-1,t}$, a linear combination of $a_1, \ldots, a_t$
- "Switching firms" do not generate autocorrelation in FEs either

◂ Back

Why both current sales and forecast predict future sales?

We want to obtain the coefficients in the following regression:

$$log(R_{t+1}) = \beta_0 + \beta_1 log(E_t R_{t+1}) + \beta_2 log(R_t) + u$$

- For informed firms, since $E_t R_{t+1}$ is the best linear predictor of $log(R_{t+1})$, we must have

$$\beta_1 = 1, \beta_2 = 0$$

- For sleeping firms, the forecast contains no information, and one can show

$$\beta_1 = \sigma_\varepsilon^2 / (\sigma_\theta^2 + \sigma_\varepsilon^2), \beta_2 = \sigma_\theta^2 / (\sigma_\theta^2 + \sigma_\varepsilon^2)$$

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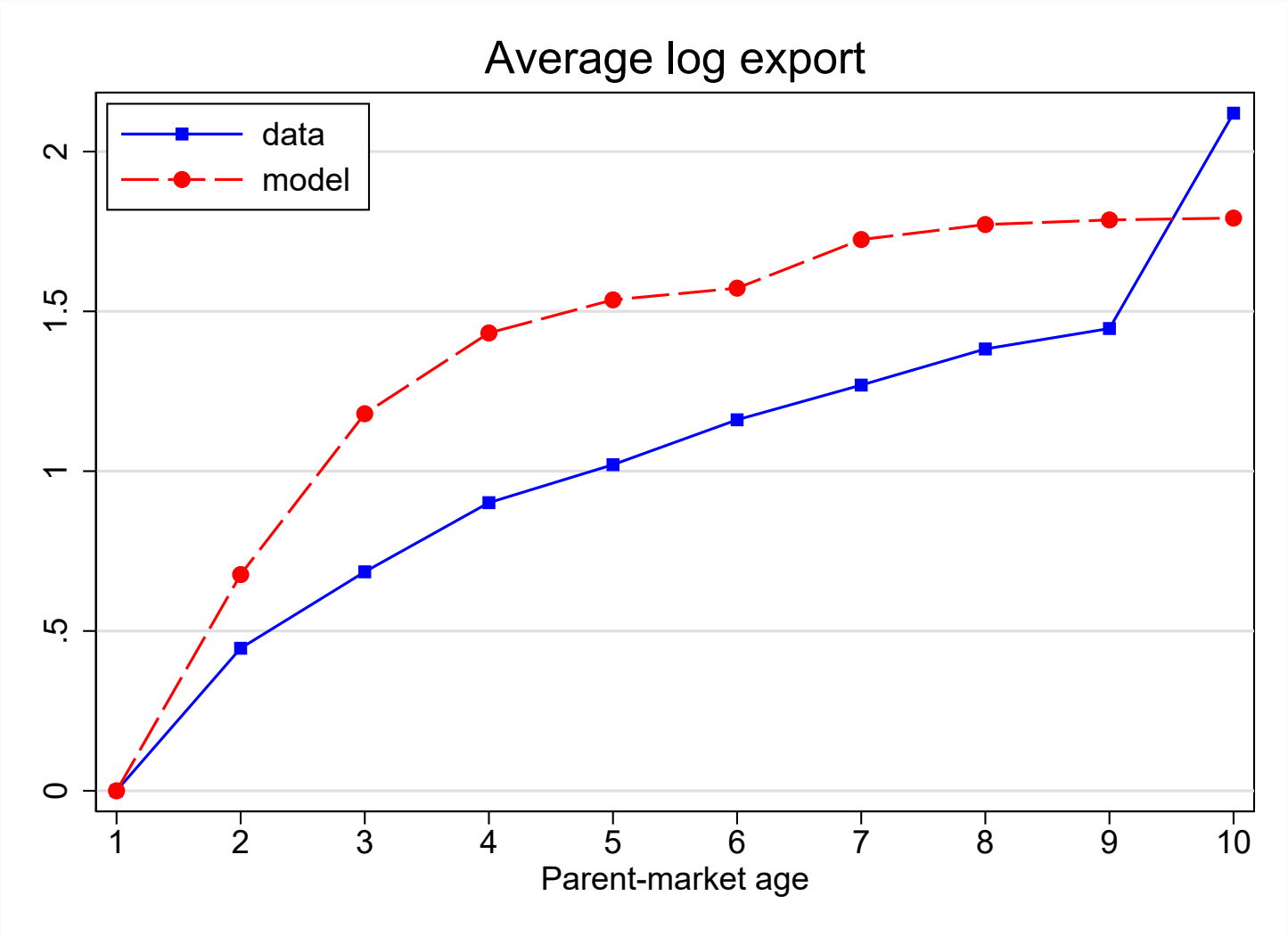
Untargeted moments: exports-age profiles

Back



Untargeted moments: exit-age profiles for exporters

Back

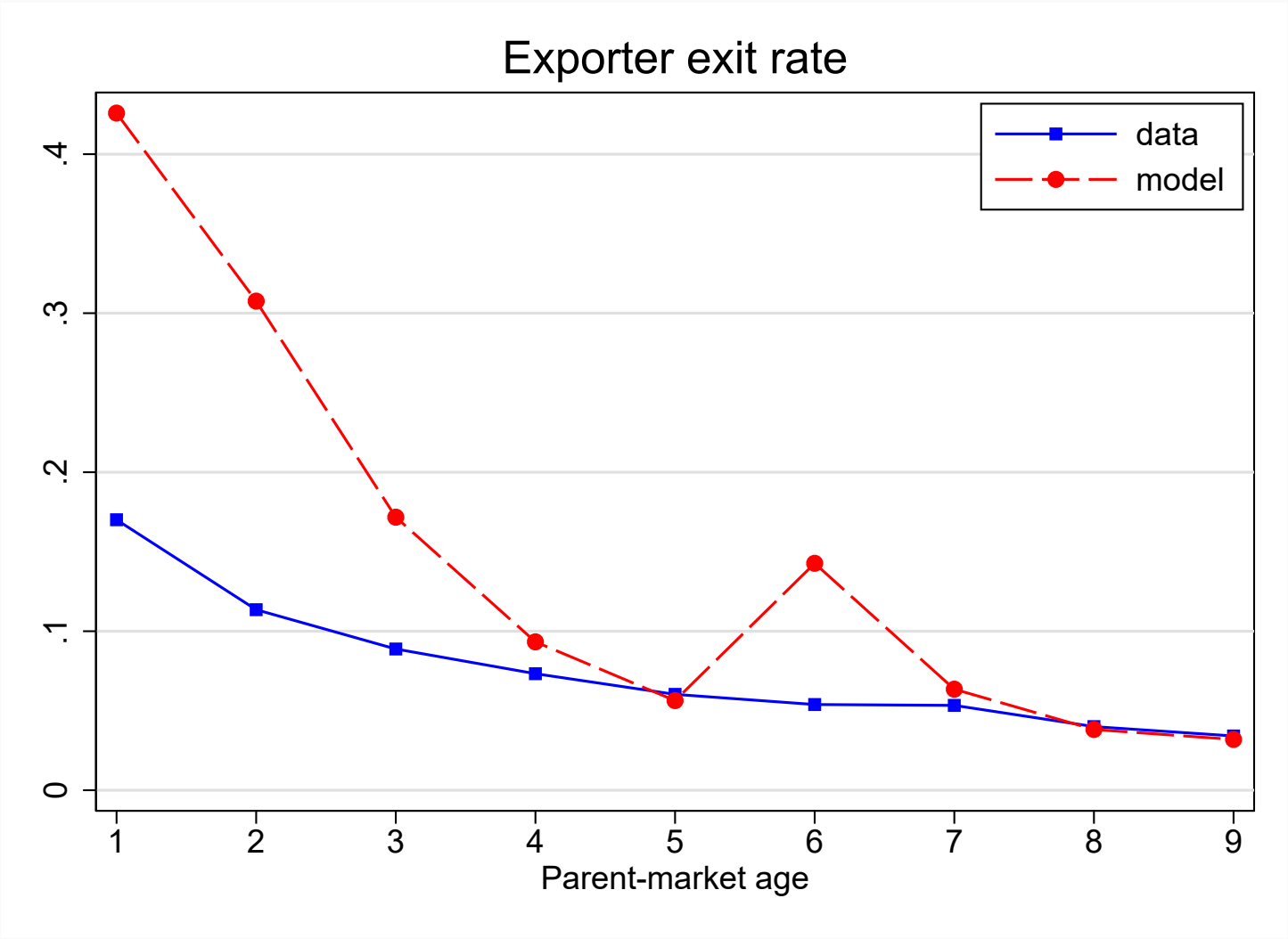


Table 24: Autocorrelation of Forecast Errors

Dep.Var: $FE^{\log}(t, t+1)$	Data		Model	
	(1)	(2)	(3)	(4)
$FE^{\log}(t-1, t)$	0.093***	-0.096***	0.028***	-0.084***
	(0.009)	(0.009)	(0.008)	(0.007)
Year FE	No	No	Yes	Yes
Country-year FE	Yes	Yes	No	No
Industry-year FE	Yes	Yes	No	No
Affiliate FE	No	Yes	No	Yes
N	44161	42501	23294	23038
R^2	0.166	0.366	0.002	0.138

Standard errors are clustered at affiliate level, * 0.10 ** 0.05 *** 0.01. In the first column, only first-time entrants into particular countries are included.

◂ Back

Table 25: Both forecast and past sales predict future sales

Dep.Var: $\log(R_t)$	Data (1)	Model (2)
$\log(E_{t-1}(R_t))$	0.693^{***}	0.965^{***}
	(0.013)	(0.008)
$\log(R_{t-1})$	0.278^{***}	0.036^{***}
	(0.013)	(0.008)
N	60034	23294
R^2	0.951	0.984
Level of Fixed Effects	Country-Year, Industry-Year	Year

Standard errors are clustered at affiliate level, * 0.10 ** 0.05 *** 0.01. In the first column, only first-time entrants into particular countries are included.

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