Uncertainty, Imperfect Information and Learning in the International Market

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  - How does distance affect it?

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  - How does firm heterogeneity affect it (age, experience, size...)?
  - How does distance affect it?
- Can we provide evidence on how firms solve problem of imperfect information and uncertainty over life cycle?
- How do different types of shocks (time-invariant and transitory) affect *dynamic* trade/MP (multinational production) patterns, resource allocation and aggregate productivity via learning channel?

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  - Firm-level uncertainty declines with firm age (and size).
  - Firm-level uncertainty declines with previous export experience.
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  - Positively correlated FEs over time, and this positive correlation increases with distance from Japan.
- Quantify role of two types of shocks and learning for dynamic trade/FDI patterns, (dynamic) resource allocation and welfare.
  - Difference between uncertainty and imperfect information: relationship with distance.
  - Time-invariant and transitory shocks have different implications for dynamic resource allocation and aggregate productivity.

Key variable

- Japanese MNE data: each affiliate reports its *projected sales* next year
- *Forecast error (FE)*: difference between the realized sales and projected sales

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

- Use $|FE|$ and $var(FE)$ as measures for firms' uncertainty,as we have point forecasts only.

Quantify role of uncertainty and learning

- Quantitative model: exporting and MP (or FDI) choices + dynamic learning model (Arkolakis et al., 17) with sticky information (Mankiw and Reis 2002)
  - Can replicate the three empirical facts about $|FE|$
  - Qualitatively match dynamics of $|FE|$, sales growth and exits
- Counterfactual experiments:
  - change in variance of time-invariant shock
  - change in variance of transitory shock

Related Literature

- Uncertainty and learning in foreign markets
  - Policy uncertainty: Handley and Limao (14, 15), Carballo (15)
  - Learning: Fernandes and Tang (14), Timoshenko (15), Conconni et al. (16), Morales and Dickstein (16), Arkolakis et al. (17)

New: Measure firms' expectation and provide *direct* evidence for imperfect information and learning: difference between *uncertainty* and *imperfect information*.

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- Micro- and macro-level uncertainty: Bloom (09), Bloom et al. (16, 17)
- Survey data on macro-level forecasts: Coibion and Gorodnichenko (12, 15), Andrade and Le Bihan (13), Bachmann et al. (13, 17), Morikawa (13, 16a, 16b, 17)

  New: Use micro-level forecast data to show how *firm heterogeneity* and *distance* affect *endogenous* firm-level uncertainty and information imperfection.

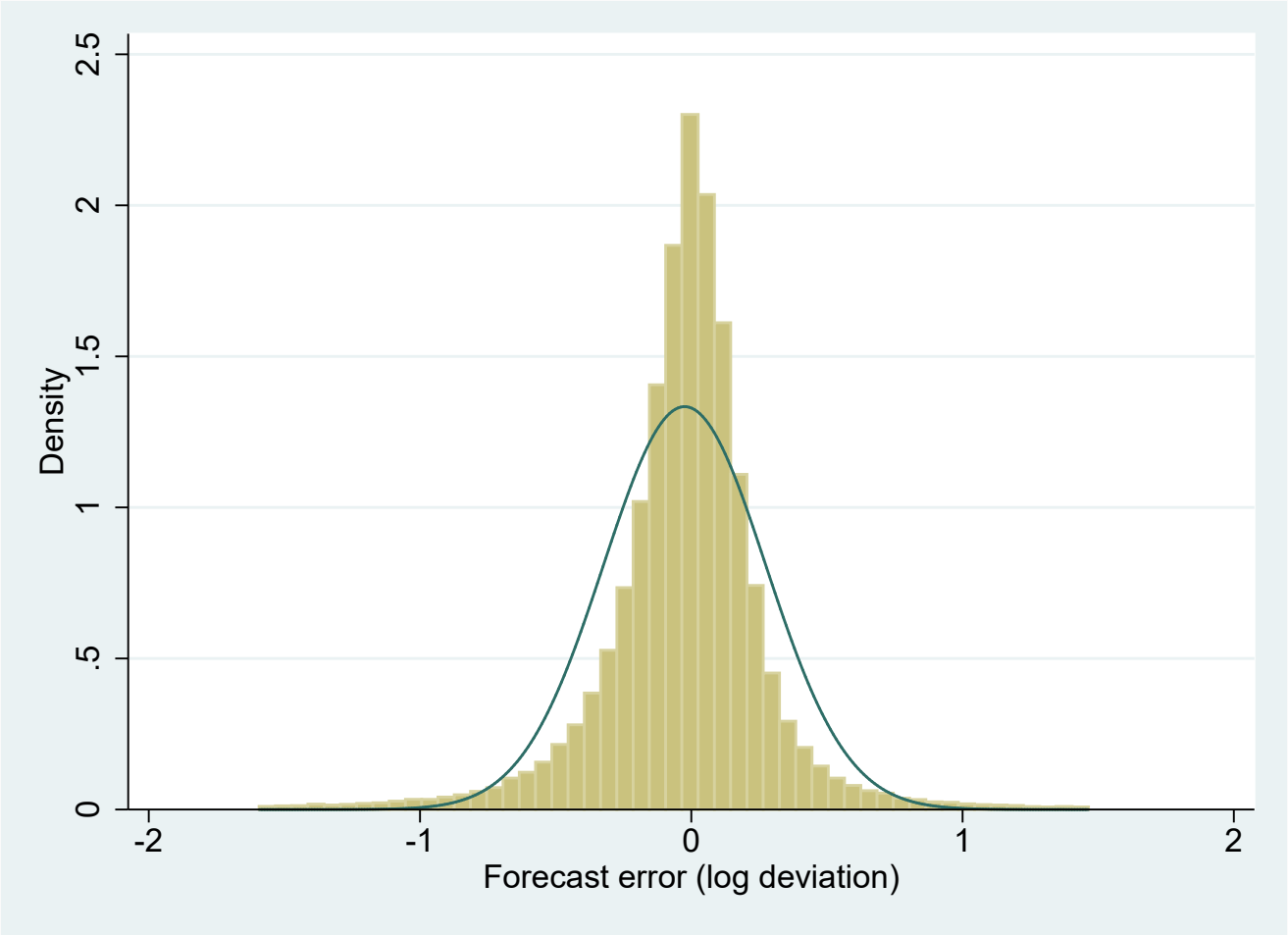
Facts about Forecasts and Forecast Errors

Data

- Japanese firm-level datasets prepared by the Ministry of Economy, Trade and Industry, 1995 - 2013
  - Basic Survey of Japanese Business Structure: firms with 50+ employees and ¥30 mil assets (in all manufacturing and some service sectors), provides export info, 28000 firms each year (on average)
  - Basic Survey of Overseas Business Activities: overseas affiliates of Japanese MNEs, 3200 parents 17000 affiliates each year (on average)
  - Merged data: 2300 parents 14000 affiliates each year
- Affiliates report their "projected sales" for the next fiscal year

Definition and distribution of FE

- We define forecast error as $FE_t^{\log} = \log\left[R_{t+1} / E_t\left(R_{t+1}\right)\right]$
- Distribution of $FE_t^{\log}$



Descriptive statistics of FE

- Two alternative measures of FE:
  - Percentage deviation $FE_t^{pct} = R_{t+1} / E_t\left(R_{t+1}\right) - 1$
  - Residual log deviation (control country-year and industry-year fixed effects) $\hat{\varepsilon}_{FE^{\log}} = FE_{it}^{\log} - \hat{\delta}_{ct} - \hat{\delta}_{st}$ (90% of variation in $FE_{it}^{\log}$)
- We trim extreme values.
- Basic facts:
  - Mean of FE is very close to zero.
  - Mean of $|FE|$ is about 20% (on average firms under-/over-predict sales by 20%)

Summary Statistics of FE

Table 1: Summary statistics for forecast errors

	Obs.	mean	std. dev.	median
FE^{log}	131268	-0.025	0.299	-0.005
FE^{pct}	131771	0.016	0.332	-0.006
$\lvert FE^{log} \rvert$	131268	0.200	0.224	0.130
$\lvert FE^{pct} \rvert$	131771	0.203	0.263	0.130
$\lvert \hat{\epsilon}_{FE^{log}} \rvert$	130968	0.184	0.213	0.116

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.

Validity of Forecast and FEs

- Sales forecasts are reported by affiliates to Japanese government (i.e., not to headquarters directly) $\rightarrow$ strategic reporting is less worrisome.
- Sales forecasts predict next period sales, employment and investment.
- Much stronger predictive power than past sales.

Sales forecasts predict sales next period

Table 2: Projected Sales and Realized Sales

	Dependent Variable: $log(Sales)_t$					
Sample:	all	all	all	manufacturing	service	survivors
$log(SalesForecast)_{t-1}$	0.713***	0.618***	0.592***	0.588***	0.590***	0.623***
	(0.010)	(0.012)	(0.014)	(0.014)	(0.020)	(0.017)
$log(Sales)_{t-1}$		0.128***	0.082***	0.127***	0.112***	0.113***
		(0.008)	(0.014)	(0.008)	(0.015)	(0.011)
$log(Sales)_{t-2}$			0.047***			
			(0.006)			
N	126501	125145	104967	74684	49668	21449
R^2	0.960	0.962	0.965	0.965	0.961	0.959
Affiliate Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country-year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. The first three columns use all observations. The fourth column uses observations (i.e., affiliate-year) whose parent firms are in manufacturing sectors. The fifth column uses observations whose parent firms are in service sectors. The last column use affiliates who have survived for at least five consecutive years.

Sales forecasts predict other variables

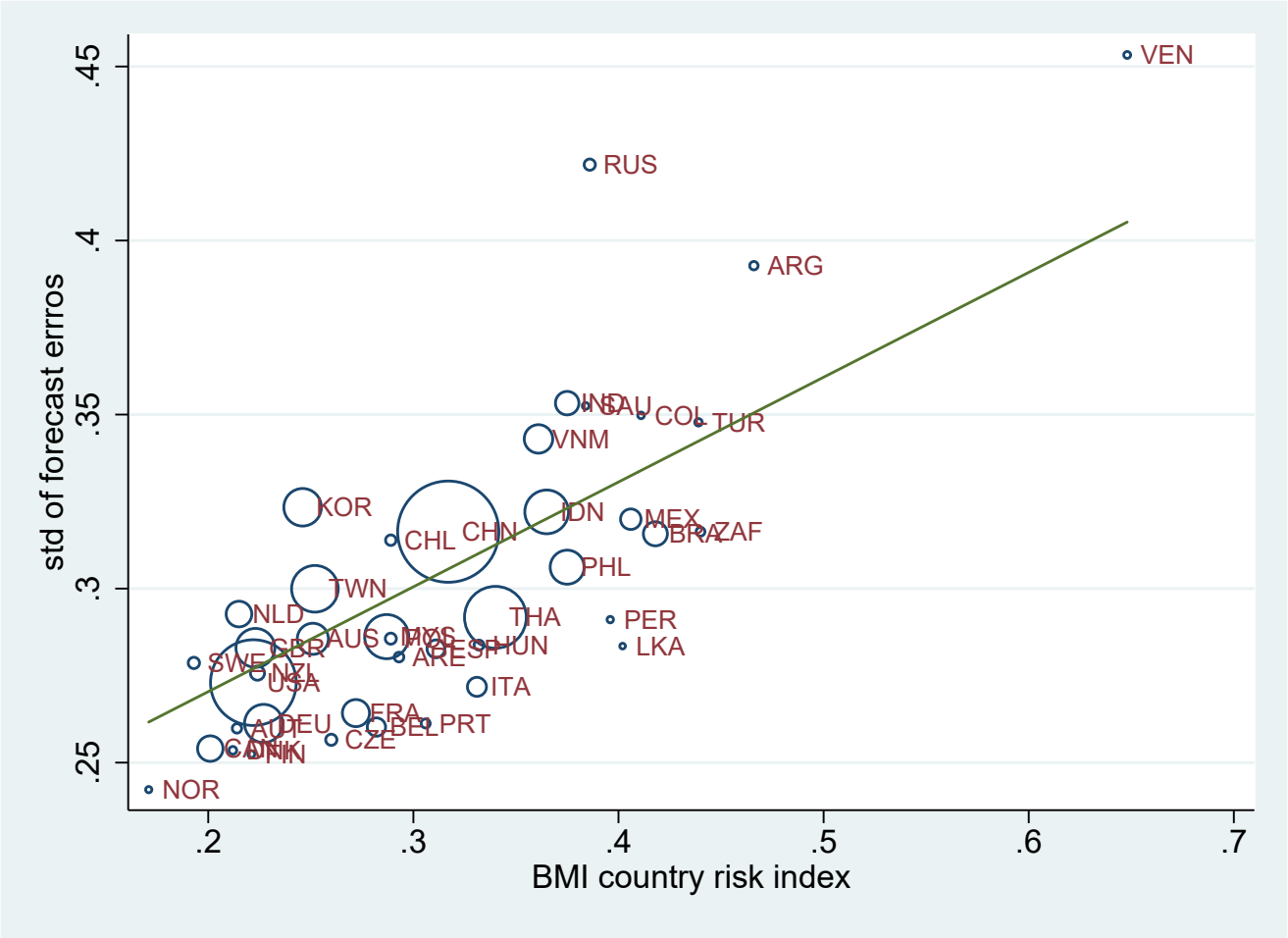
Table 3: Projected Sales and Realized Investment and Employment

Dependent Var:	$log(Employment)_t$	$log(Investment)_t$	$Investment_t > 0$
$log(SalesFore)_{t-1}$	0.266***	0.509***	0.059***
	(0.014)	(0.024)	(0.004)
$log(Sales)_{t-1}$	0.081***	-0.129***	-0.011***
	(0.005)	(0.014)	(0.003)
N	123887	77217	105535
R^2	0.958	0.779	0.615
Affiliate Fixed Effect	Yes	Yes	Yes
Country-year Fixed Effect	Yes	Yes	Yes
Industry-year Fixed Effect	Yes	Yes	Yes

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. All columns use all observations.

Empirical Fact 0: Aggregate uncertainty and firm-level uncertainty

- Var(FE) is correlated with country-level risk index (all firms).



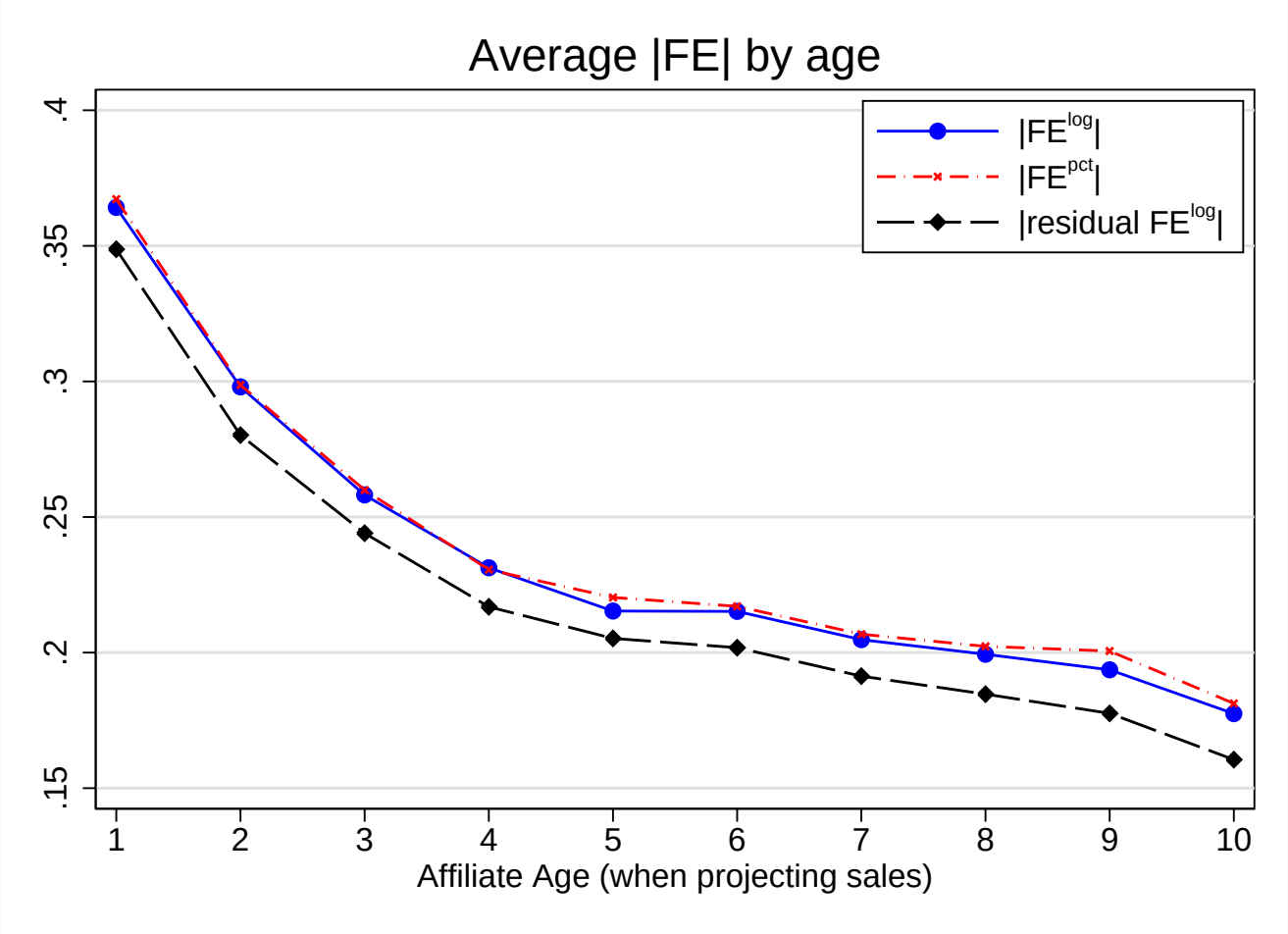
|FE| and aggregate risk/volatility (within-firm and destination market-specific)

Table 4: Affiliates' uncertainty and country risk index

	(1) $\lvert FE^{log} \rvert$	(2) $\lvert FE^{pct} \rvert$	(3) $\lvert \hat{\epsilon}_{FE^{log}} \rvert$	(4) $\lvert FE^{log} \rvert$	(5) $\lvert FE^{pct} \rvert$	(6) $\lvert \hat{\epsilon}_{FE^{log}} \rvert$
Country risk index	0.275^{***}	0.261^{***}	0.264^{***}			
	(0.042)	(0.041)	(0.049)			
$\sigma(\Delta log(GDP))$				1.061^{**}	1.076^{***}	0.991^{**}
				(0.406)	(0.378)	(0.433)
N	129886	130388	129625	129807	130309	129559
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	0.061			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. Country risk index (BMI research database) is an index from zero to one that measures the overall risk of the economy, such as an economic crisis or a sudden change in the political environment , with one being the most risky environment. $\sigma(\Delta log(GDP))$ is the standard deviation of real GDP growth rate of the host country since 1990, calculated from Penn World Table 9.0.

Empirical Fact 1: |FE| declines with affiliate age



Empirical Fact 1: regression of |FE| w.r.t. affiliate age

Table 5: Age effects on the absolute forecast errors

	All	All	All	Survived 7 years
Age=2	-0.060	-0.059	-0.061	-0.067
	(0.008)	(0.008)	(0.009)	(0.013)
Age=3	-0.108	-0.096	-0.087	-0.092
	(0.008)	(0.008)	(0.009)	(0.013)
Age=4	-0.136	-0.120	-0.104	-0.105
	(0.008)	(0.008)	(0.009)	(0.012)
Age=5	-0.147	-0.128	-0.106	-0.116
	(0.008)	(0.008)	(0.009)	(0.014)
Age=6	-0.152	-0.130	-0.104	-0.120
	(0.008)	(0.008)	(0.009)	(0.013)
Age=7	-0.157	-0.135	-0.105	-0.140
	(0.008)	(0.008)	(0.009)	(0.013)
Age=8	-0.165	-0.140	-0.108	-0.133
	(0.008)	(0.008)	(0.010)	(0.014)
Age=9	-0.166	-0.142	-0.106	-0.124
	(0.008)	(0.008)	(0.010)	(0.015)
Age=10	-0.181	-0.145	-0.103	-0.124
	(0.008)	(0.008)	(0.010)	(0.014)
log(Parent Domestic Sales)		0.008	0.002	0.011
		(0.001)	(0.002)	(0.002)
log(Affiliate Sales)		-0.025	-0.059	-0.034
		(0.001)	(0.003)	(0.002)
N	130963	117048	111679	14948
R^2	0.098	0.129	0.383	0.154
Affiliate Fixed Effect	No	No	Yes	No
Industry Fixed Effect	Yes	Yes	No	Yes
Country-year Fixed Effect	Yes	Yes	Yes	Yes

Empirical Fact 2: previous exporting reduces |FE|

- Previous work suggests export experience reduces uncertainty in FDI (Conconi et al., 16)
- Data and sample selection
  - We only know the parent firms' exports to regions (Asia, North America, Europe, Middle East, Africa, Latin America, Oceania)
  - Examine first-time entrants into the host-country/region
  - Focus on manufacturing parent firms and manufacturing or distributional-oriented affiliates (wholesalers + retailers).

Empirical Fact 2: previous exporting reduces |FE|

Table 6: Summary Statistics

	Frequency	Percent
0	191	27.4
1	50	7.2
2	47	6.7
3	50	7.2
4	38	5.4
5	47	6.7
6	39	5.6
7	32	4.6
8	32	4.6
9	22	3.2
10	38	5.4
11	33	4.7
12	19	2.7
13	23	3.3
14	16	2.3
15	21	3.0
Total	698	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.

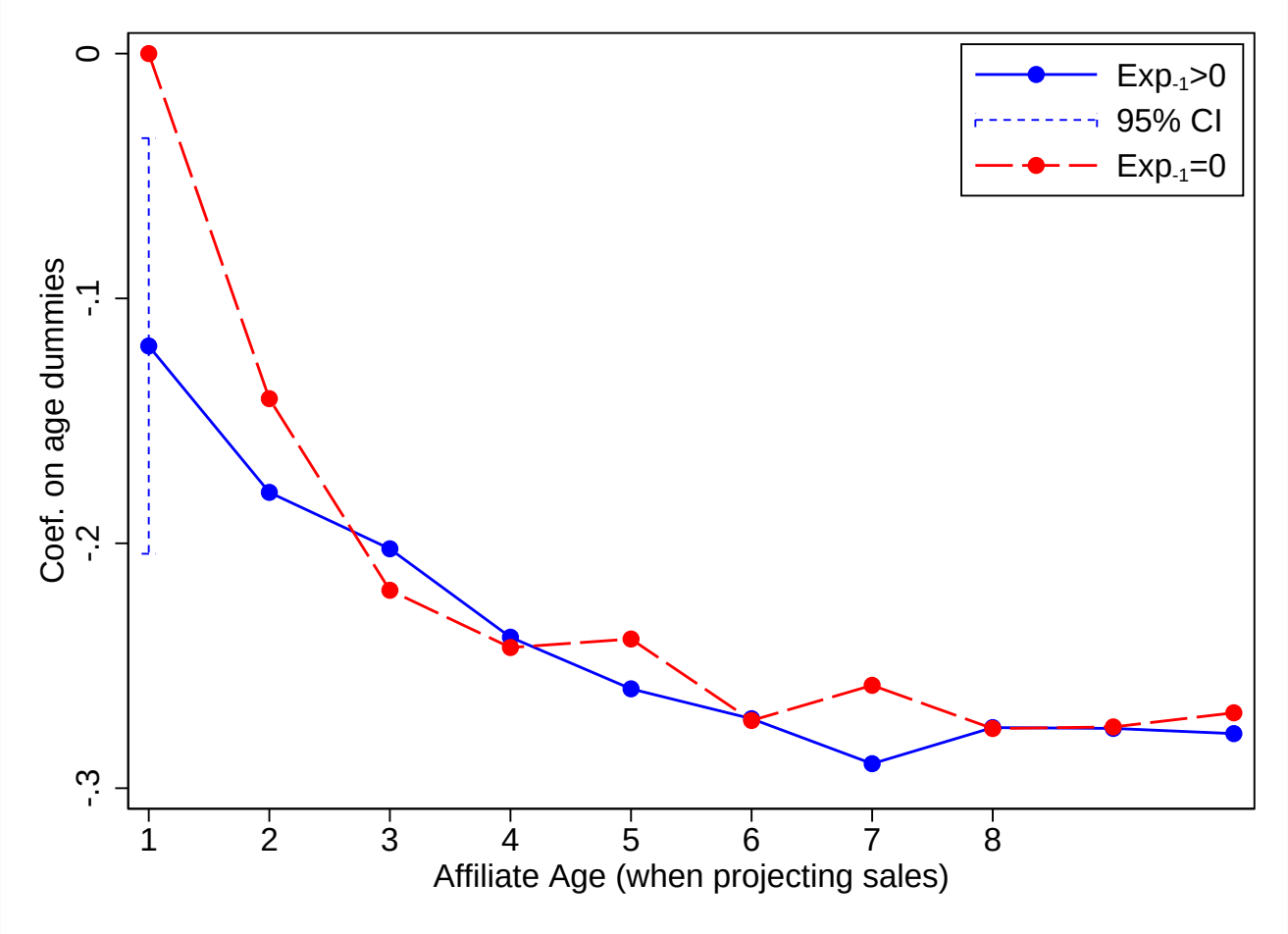
Empirical Fact 2: previous exporting reduces $|FE|$

Table 7: Learning from Exporting: basic regression

	Dependent Variable: $\lvert FE^{log} \rvert$			
	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	-0.159**			
	(0.065)			
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.151**		
		(0.064)		
$Exp \quad Expe. > 0$			-0.132*	
			(0.070)	
$Exp \quad Expe.$				-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.

Empirical Fact 2: previous exporting and |FE| - age profile



Empirical Fact 2: robustness

- 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

Empirical Fact 3: FEs are positively correlated over time

Table 8: 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 firms	all manufacturing	entrants	survivors	entrants and survivors
N	178140	108135	11013	19968	9799

Notations: Top and bottom one percent observations of forecast errors are trimmed. Manufacturing firms including firms in wholesalers as well. 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 refers to manufacturing affiliates that entered the destination markets during our sample period.

Empirical Fact 3: Positive correlated goes down with firm age

Table 9: Serial correlation of forecast errors for different age groups

	age: 2-5	age: 6-8	age: 9-12	age$\geq$13
corr. $(FE^{\log}_{t-1,t}, FE^{\log}_{t,t+1})$	0.157^{***}	0.123^{***}	0.103^{***}	0.109^{***}
Manufacturing firms only?	Yes	Yes	Yes	Yes
N	13985	14278	18995	54021

Notations: Top and bottom one percent observations of forecast errors are trimmed. Manufacturing affiliates including those in retail and wholesale sectors as well. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Empirical Fact 3: regression of $FE_{t,t+1}$ on $FE_{t-1,t}$

Table 10: Regression for the serial correlation of forecast errors

	(1)	(2) $FE^{\log}_{t,t+1}(sales)$	(3)
$FE^{\log}_{t-1,t}(sales)$	0.106^{***}	0.131^{***}	0.120^{***}
	(0.00689)	(0.0138)	(0.0187)
Type of firms	manufacturing	manufacturing survivors	manufacturing entrants
Industry-year FE	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes
N	67790	13160	6787
adj. R^2	0.148	0.169	0.219

Notations: Top and bottom one percent observations of forecast errors are trimmed. Standard errors are in parentheses and clustered at the affiliate level. Manufacturing firms including firms in wholesalers as well. 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 refers to manufacturing affiliates that entered the destination markets during our sample period.

Empirical Fact 3: regression with Parent Fixed Effect

Table 11: Correlation of sales forecast errors (including parent firm FEs)

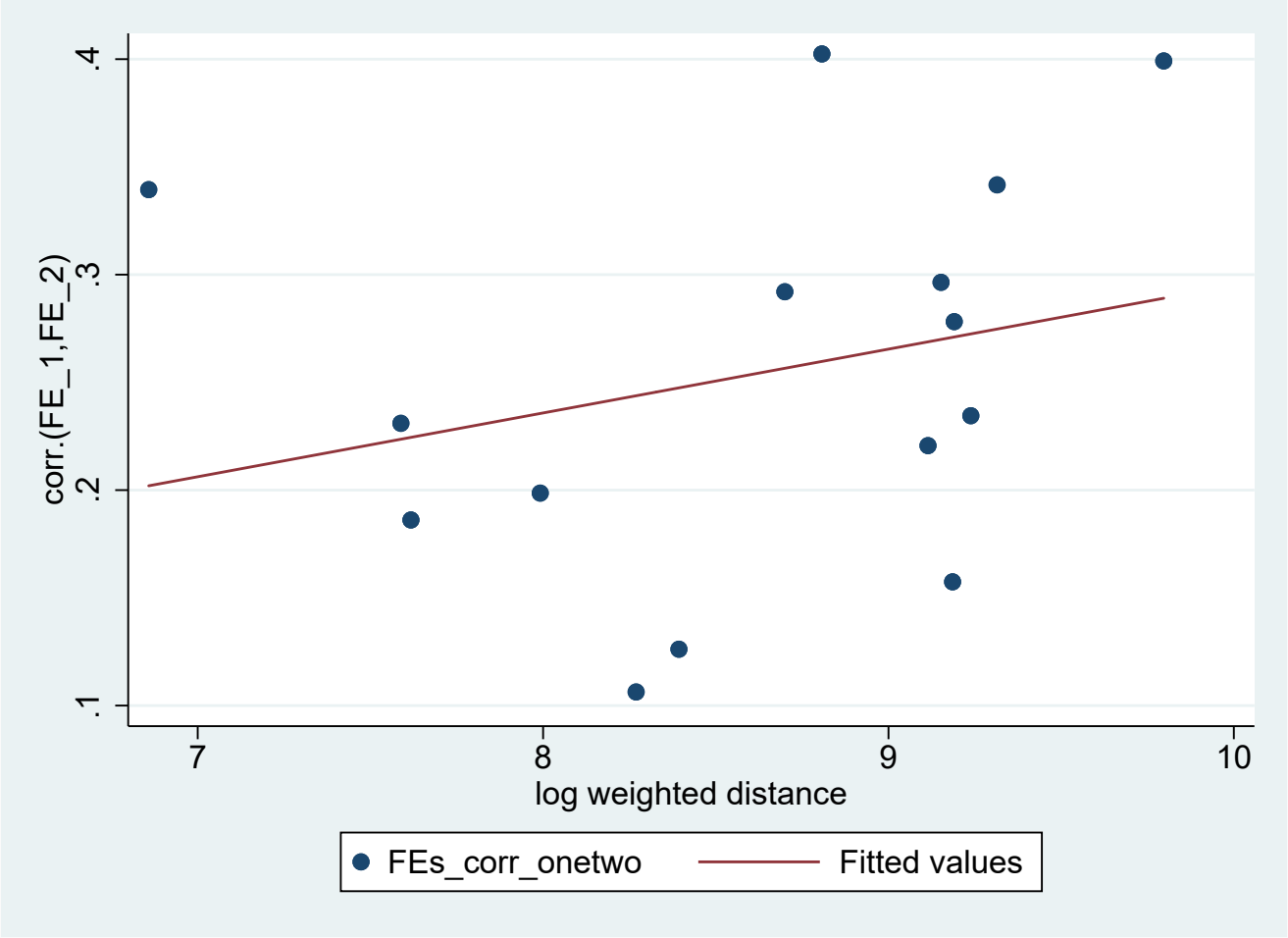
	(1) $FE^{pct}_{t,t+1}$	(2) $FE^{\log}_{t,t+1}$	(3) $\hat{\epsilon}_{FE^{log}_{t,t+1}}$	(4) $FE^{pct}_{t,t+1}$	(5) $FE^{\log}_{t,t+1}$	(6) $\hat{\epsilon}_{FE^{log}_{t,t+1}}$
$FE^{pct}_{t-1,t}$	0.0656***			0.0703***		
	(0.00600)			(0.00757)		
$FE^{\log}_{t-1,t}$		0.0642***			0.0631***	
		(0.00526)			(0.00665)	
$\hat{\epsilon}_{FE^{log}_{t-1,t}}$			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

Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Top and bottom one percent observations of forecast errors are trimmed. Standard errors are in parentheses and clustered at the affiliate level. Manufacturing affiliates including those in retail and wholesale sectors as well.

Empirical Fact 4: Distance and information flows

- Distance affects information flows (especially within MNEs), as parent firm and affiliate need to coordinate and communicate.
- This is especially true for Japanese MNEs.
- Naturally, we should observe positive correlation between distance (from Japan to destination economy) and measure of information imperfection (or rigidity): serial correlation of FEs.

Distance and Information Flows: Evidence

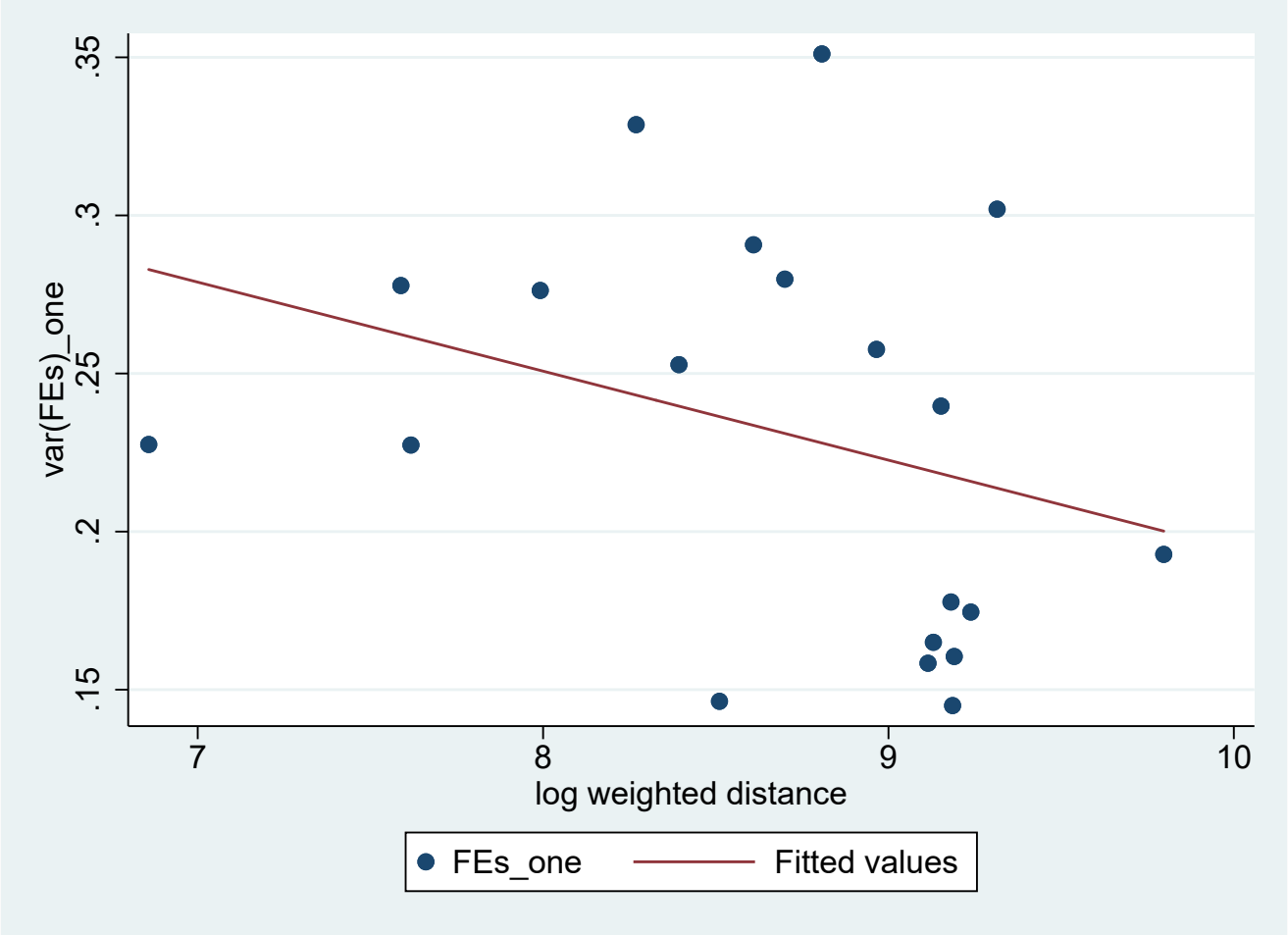


▸ CorrFEs23 ▸ regression for CorrFEs

Empirical Fact 5: Economic volatility and precision of forecasts

- More volatile and uncertain economic conditions (i.e., emerging markets) should cause imprecise forecasts and larger variance of FEs.
- This is probably not related to the distance from Japan per se.
- However, most economies that are close to Japan are emerging markets.

Economic volatility and Precision of forecasts: Evidence



▸ VarFEs10 ▸ regression for VarFEs1 ▸ regression for VarFEs10 ▸ Correlating between (VarFE1, VarFE10)

Empirical Fact 6: Experienced NNEs set up bigger affiliates abroad after entry

▸ Theory

Table 12: Export experience is related to characteristics of affiliates

	(1) $log\left(\frac{sales}{employment}\right)_{sub}$	(2) $log(sales)_{sub}$	(3) $log(employment)_{sub}$
$Exp_{-1} > 0$	0.568^{**}	0.471	0.0665
	(0.280)	(0.333)	(0.149)
N	778	811	1241
R^2	0.759	0.699	0.613
Industry-year Fixed Effect	Yes	Yes	Yes
Country-year Fixed Effect	Yes	Yes	Yes

Std. err. clustered at the affiliate level. * 0.10 ** 0.05 *** 0.01. First time entrant is defined at the country level. Exporting experience is defined as whether the parent firm exported one year prior to FDI entry. The sample includes patent firms in the manufacturing sector and affiliates that are in the manufacturing or (wholesale and retail) sector.

Summary of facts

- A set of new facts:
  - Positive correlation between aggregate-level and micro-level uncertainty.
  - Firm-level uncertainty of sales (i.e., variance of FEs) declines with firm age.
  - Firm-level uncertainty of sales (i.e., variance of FEs) declines with previous export experience.
  - Positively correlated FEs over time.
  - Correlation is positively related to distance.

Industry Equilibrium Model and Quantification

Major elements of the model

1. Bayesian updating (learning) about demand as in Arkolakis et al. (2017)
2. Information rigidity similar to Mankiw and Reis (2002)
3. Dynamic choices of exporting and multinational production (MP). The former has lower entry costs but higher variable costs (i.e., iceberg trade cost).

- 1 helps to generate reduction in $var(FE)$ over firms' life cycles
- 1 and 3 can rationalize "learning from exporting"
- 2 helps to generate positive autocorrelation in FEs

Setup

- Time is discrete
- Two-layer consumer demand

$$U_t = \left(\sum_i \chi_i^{\frac{1}{\delta}} Q_{it}^{\frac{\delta-1}{\delta}} \right)^{\frac{\delta}{\delta-1}}, Q_{it} = \left(\int_{\omega \in \Sigma_{it}} e^{\frac{a_t(\omega)}{\sigma}} q_t(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}.$$

where $a_t(\omega)$ follows

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

- Demand for a particular Japanese variety

$$q_t(\omega) = \frac{\tilde{Y}_t}{\tilde{P}_t^{1-\delta}} \chi_{jp} P_{jp,t}^{\sigma-\delta} e^{a_t(\omega)} p_t(\omega)^{-\sigma},$$

  - $\tilde{P}_t$ is the aggregate price index for all goods
  - $P_{jp,t}$ is the ideal price index for Japanese goods

Setup and state variables

- Firms can serve the foreign market via export or via FDI
  - Trade costs: (τ, f_x, f_x^e); FDI costs: $(f_m, f_m^e(\omega))$
  - Entry cost into FDI $f_m^e(\omega)$ is drawn from $logN(\mu_{f_m^e}, \sigma^2_{f_m^e})$.
    - This assumption is based on productivity ranking for experienced and inexperienced affiliates. ▸ Evidence
    - It is same as assumption adopted in Das, Roberts and Tybout (2007) and Ruhl and Willis (2017).
  - $\theta(\omega)$ follows $N(\bar{\theta}, \sigma^2_\theta)$
  - Every period, $1-\alpha$ fraction uninformed firms become informed.
- Firm produces only using labor $q_t = l_t$.
- State variables: service mode, entry cost into FDI, age, experience, information status.

Timing

1. Exogenous mass 1 of entrants draw f_m^e and θ, but θ is unknown
2. Entrants and incumbents:
   - 2.1 receive exogenous death shock with prob η
   - 2.2 decide whether to exit, becoming exporter or becoming MNE (endogenous mode switching and exit)
   - 2.3 choose employment l thus q
   - 2.4 observe a and set price p to clear the market
   - 2.5 "uninformed" firms permanently switch to "informed" status with probability $1 - \alpha$; update belief about θ

Belief updating

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^2_{n-1}

$$\mu_{n-1} = \frac{\sigma^2_\varepsilon}{\sigma^2_\varepsilon + (n-1)\,\sigma^2_\theta}\bar{\theta} + \frac{(n-1)\,\sigma^2_\theta}{\sigma^2_\varepsilon + (n-1)\,\sigma^2_\theta}\,\bar{a}_{n-1};$$

$$\sigma^2_{n-1} = \frac{\sigma^2_\varepsilon \sigma^2_\theta}{\sigma^2_\varepsilon + (n-1)\,\sigma^2_\theta}.$$

where

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

For an uninformed firm, the posterior is always $N(\mu_0, \sigma^2_0)$

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

- Informed exporter ($t \geq 2$):

$$
\begin{aligned}
& V(x, f_m^e, t, \bar{a}_{t-1}, in = 1) \\
= & \max_{o' \in \{x,m,exit\}} \Bigg(E_t \pi_{x,t} + \beta(1-\eta) E_t V(x, f_m^e, t+1, \bar{a}_t, in = 1), \\
& E_t \pi_{m,t} - w f_m^e + \beta(1-\eta) E_t V(m, f_m^e, t+1, \bar{a}_t, in = 1), V_{exit} \Bigg)
\end{aligned}
$$

- We assume they use domestic labor to pay for entry cost into FDI.
- $E_t \pi_{x,t}$ and $E_t \pi_{m,t}$ are expected profits from exporting and FDI.
- Expectations are based on information available at the beginning of period t (equivalently at end of period $t-1$).

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

- Uninformed exporter ($t \geq 2$):

$$V(x, f_m^e, t, \bar{a}_0, in = 0) = \max_{o' \in \{x, m, exit\}} \Bigg(E_t \pi_{x,t} + \beta(1-\eta)$$
$$[\alpha E_t V(x, f_m^e, t+1, \bar{a}_0, in = 0) + (1-\alpha) E_t V(x, f_m^e, t+1, a_t, in = 1)],$$
$$E_t \pi_{m,t} - w f_m^e + \beta(1-\eta)[\alpha E_t V(m, f_m^e, t+1, \bar{a}_0, in = 0)$$
$$+(1-\alpha) E_t V(m, f_m^e, t+1, a_t, in = 1)], V_{exit} \Bigg)$$

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

- Entrant:

$$V(ent, f_m^e, 1, \bar{a}_0, in = 0) \max_{o' \in \{x,m,exit\}} \Bigg(E_1 \pi_{x,t} - w f_x^e + \beta(1-\eta)$$
$$[\alpha E_1 V(x, f_m^e, 2, \bar{a}_0, in = 0) + (1-\alpha) E_1 V(x, f_m^e, 2, \bar{a}_1, in = 1)],$$
$$E_1 \pi_{m,t} - w f_m^e + \beta(1-\eta)[\alpha E_1 V(m, f_m^e, 2, \bar{a}_0, in = 0)$$
$$+(1-\alpha) E_1 V(m, f_m^e, 2, \bar{a}_1, in = 1)], V_{exit} \Bigg)$$

- MNE's value functions can be defined accordingly.

Implications of the model

- Firms cannot perfectly foresee their sales as
  - they are uncertain about θ and since they only receive signals $a = \theta + \varepsilon$.
  - some firms are uninformed
- Match lifecycle dynamics of FEs
  1. $var(FE)$ declines with age as firms gradually learn from signals and more firms become informed over time
  2. Previous export experience matters since firms accumulate same amount of information when exporting as doing FDI
  3. Positive autocorrelation of FEs is caused by uninformed firms

How do parameters affect forecast errors?

- For relatively old firms, almost all are informed and posterior $N(\mu_{t-1}, \sigma^2_{t-1})$ converges to θ – almost all FEs come from ε

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

- For uninformed firms or firms without any experience, both θ and ε lead to FEs

$$Var\left(FE^{\log}_{0}\right) = Var\left(\frac{\theta - \mu_0 + \varepsilon_1}{\sigma}\right) = \frac{\sigma^2_\theta + \sigma^2_\varepsilon}{\sigma^2}$$

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

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

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

Table 13: Standard parameters calibrated without solving the 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-specific exit rates

Calibration - without solving model

Table 14: 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

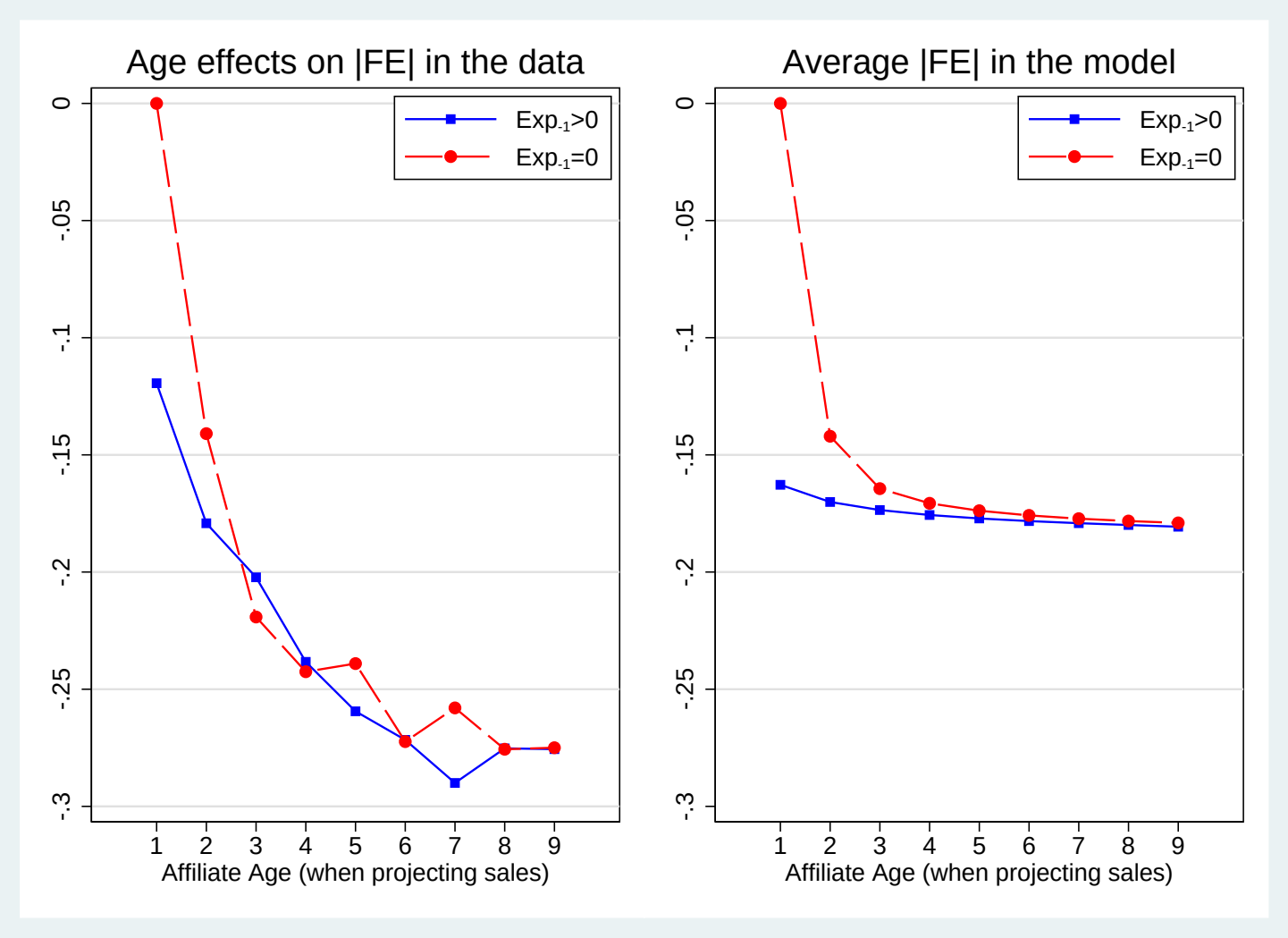
Calibration - solve model and match moments

Table 15: Parameters calibrated by solving the model and matching moments

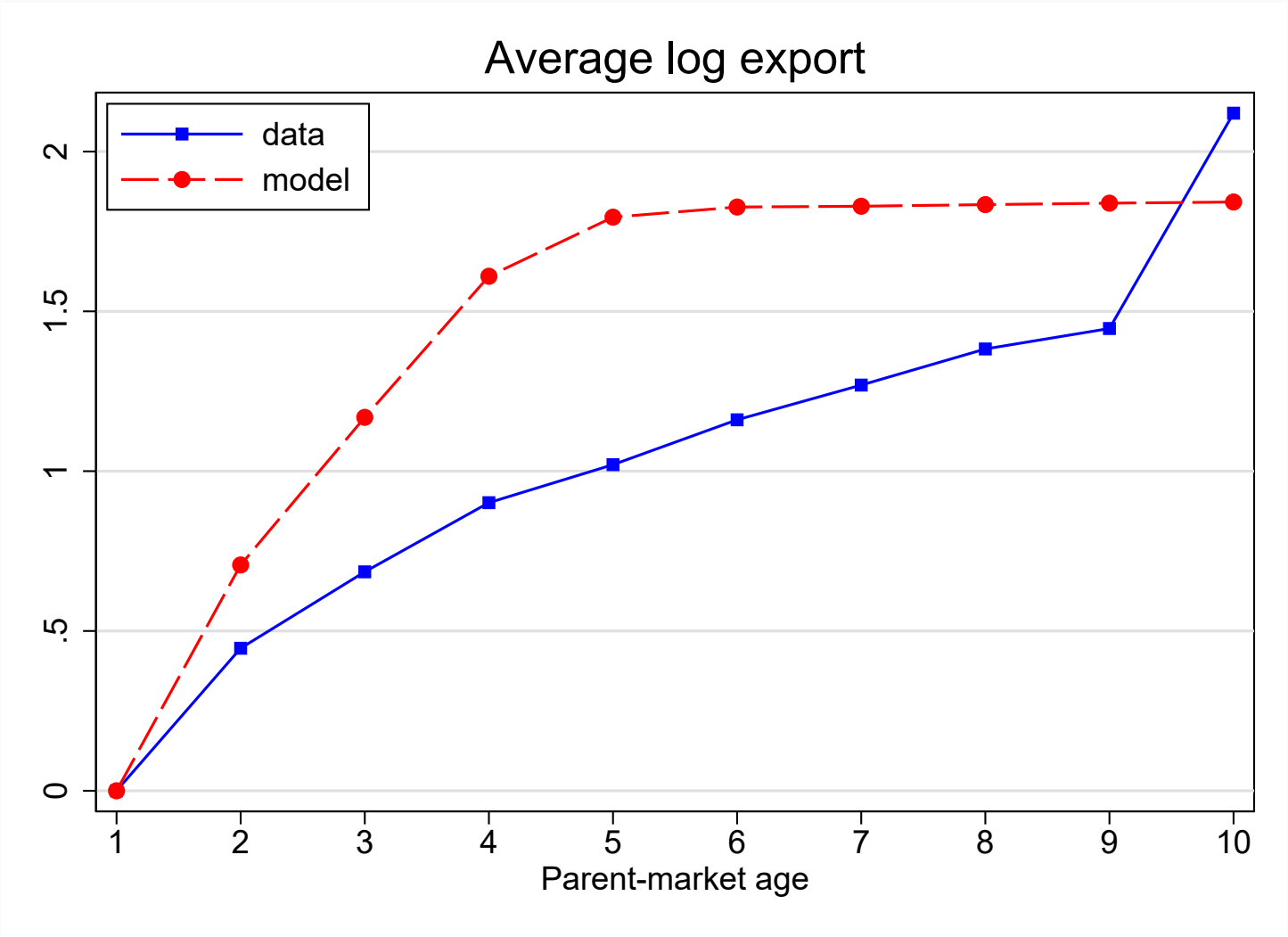
Parameters	Value	Description	Moments	Data	Model
f_x	0.0056	export fixed cost	average exit rate of exporters	0.10	0.11
$\mu_{f_m^e}$	1.58	mean of log FDI entry cost	fraction of exporters among active firms	0.70	0.69
$\sigma_{f_m^e}$	2.45	Std of log FDI entry cost	fraction of experienced MNEs at age 1	0.73	0.75
τ	1.46	iceberg trade cost	Exporter sales share	0.21	0.21

Untargeted moments

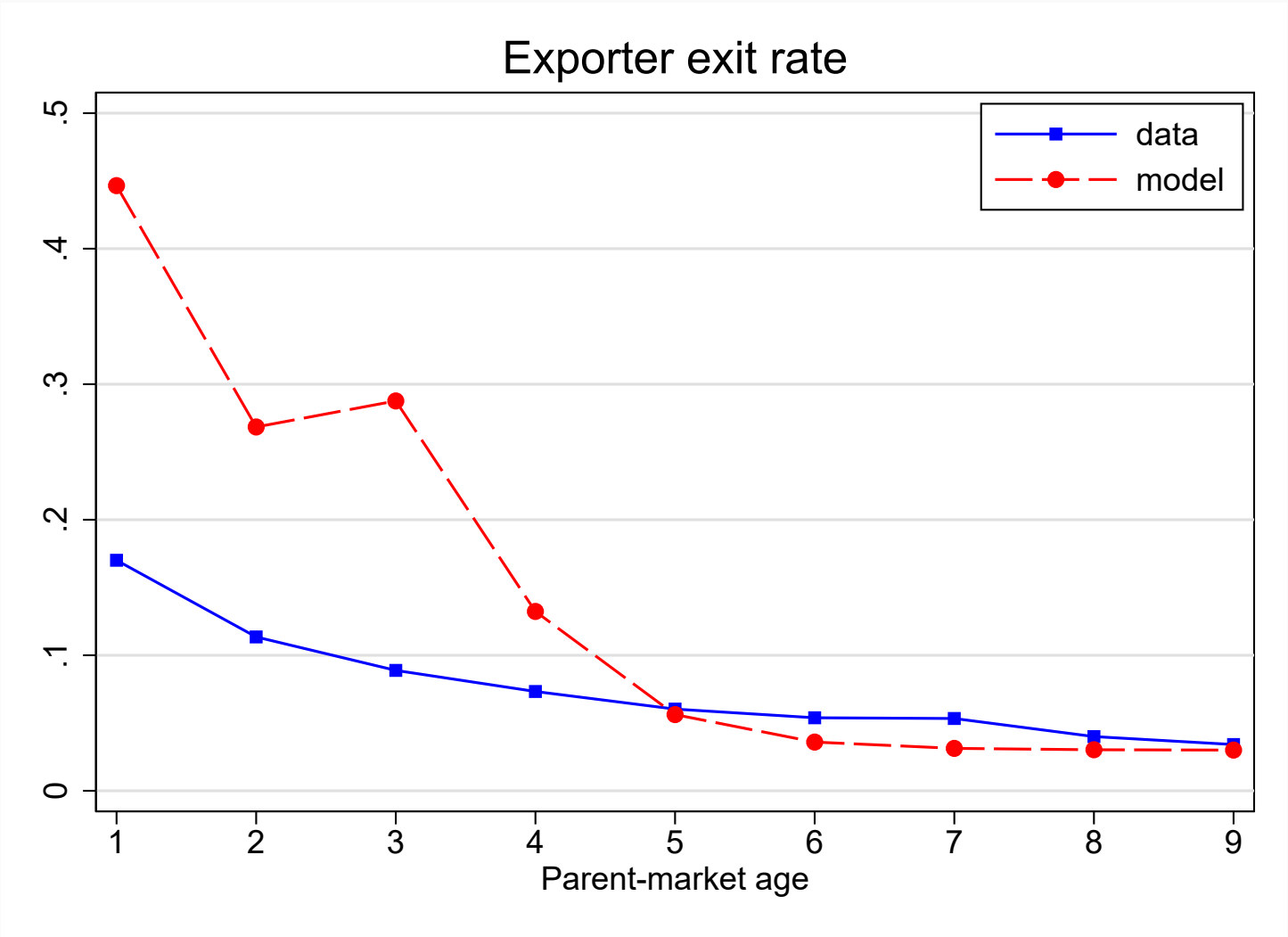
- FE-age profiles for MNE with and without export experience



Untargeted moments: exports-age profiles



Untargeted moments: exit-age profiles for exporters



Overview of counterfactuals

- Change uncertainty σ_ε and σ_θ.
  - $|FE|$ differs across countries and helps to identify σ_θ and σ_ε
  - Two sources of uncertainty have different implications for dynamic trade/MP patterns, dynamic resource allocation and aggregate productivity.
- Caveat one: Volatility, σ_ε, can come either from demand side or from supply side.
- Caveat two: σ_θ just reflects heterogeneity in production technology or in consumers' preferences.

Variation of parameters across countries/regions

- We focus on *inexperienced* MNEs and utilize var(FE_1) and var(FE_{10+}) to calculate σ_ε^2 and σ_θ^2 for different countries/regions
- We only have enough observations for Asia (excluding China), China, North America and Europe.

Table 16: Cross-country difference in variance of shocks

Region/Country	Asia (non-China)	China (P.R.C.)	North America	Europe
Moments				
Std. dev. of $FE_{1,2}$	0.48	0.62	0.45	0.42
Std. dev. 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

Rationales for counterfactuals

- Firm-level volatility (firm age ≥ 8): positively related to country-level risk.
- Sudden change in political environment and instability of government policies affect firm-level volatility (demand and supply).

Table 17: Firm-level Volatility 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.

Rationales for counterfactuals (cont.)

- EPU positively affects firm-level volatility (firm age ≥ 10):
  - 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 18: 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

Standard errors are clustered at the country level, * 0.10 ** 0.05 *** 0.01. FE^{log} is the log deviation of the realized sales from the projected sales; FE^{pct} is the percentage deviation of the realized sales from the projected sales; $\hat{\epsilon}_{FE^{log}}$ is the value of the residual forecast error, which we obtain by regressing FE^{log} on a set of industry-year and country-year fixed effects. Economic Policy Uncertainty Index is obtained from EPU website. The 19 economies included here are Australia, Brazil, Canada, Chile, China, Germany, Spain, France, UK, India, Ireland, Italy, Korea, Mexico, Netherland, Russia, Singapore, Sweden and the U.S.

Transitory shock and dynamic allocation

- Increase in σ_ε *reduces* aggregate productivity and welfare via affecting *dynamic allocation*.

Transitory shock and dynamic allocation

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- $\sigma_\varepsilon \uparrow \Rightarrow$ signal-to-noise ratio $\downarrow \Rightarrow$ learning becomes less effective.
  1. Allocation between MP and exporting: more entrants choose to enter FDI directly and learning prior to MP is less effective $\Rightarrow$ less information revealed when deciding whether or not to enter MP.
  2. Allocation between operation and exiting: learning is less effective $\Rightarrow$ less information revealed when deciding whether or not to exit.

Transitory shock and dynamic allocation

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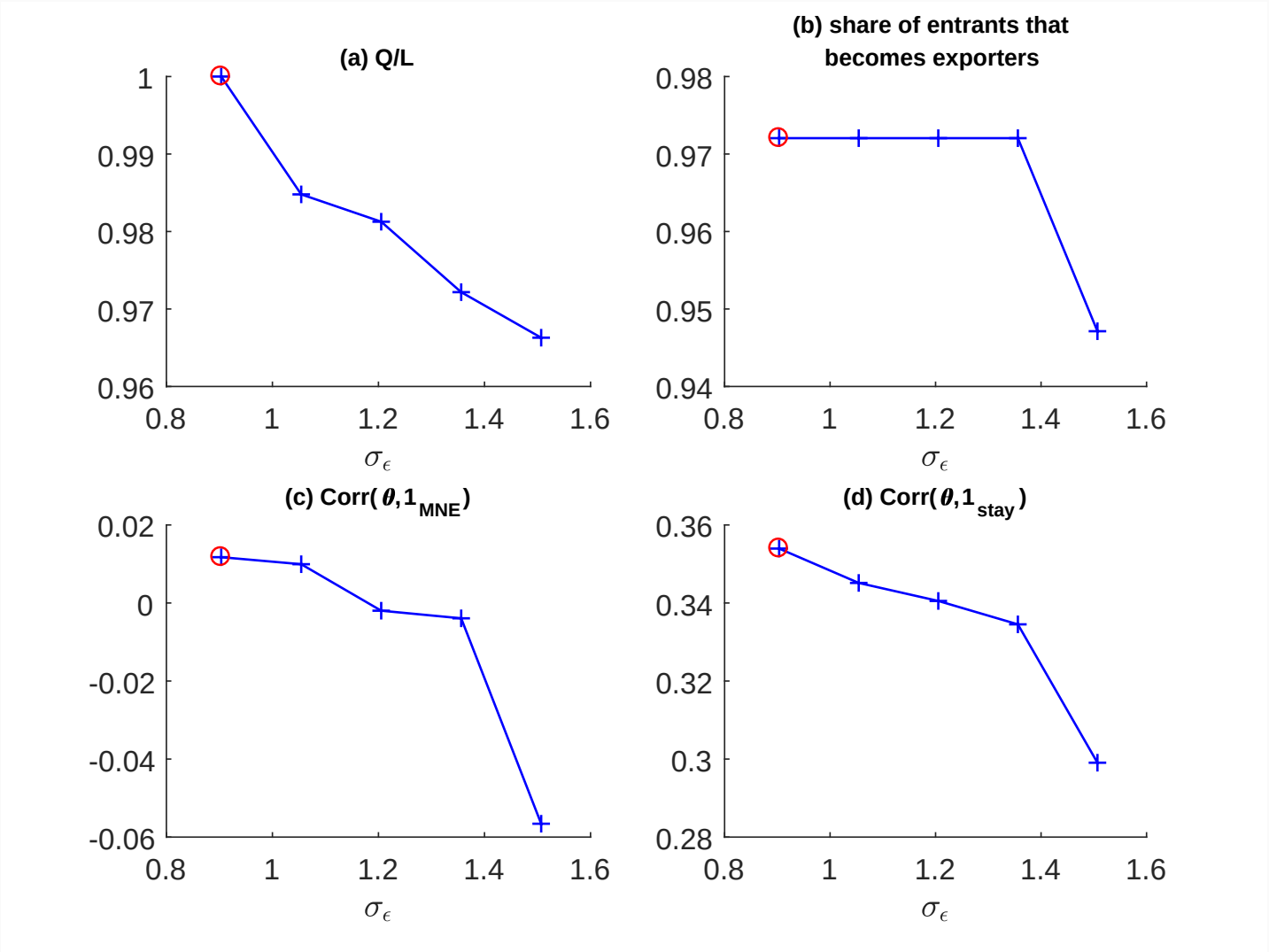
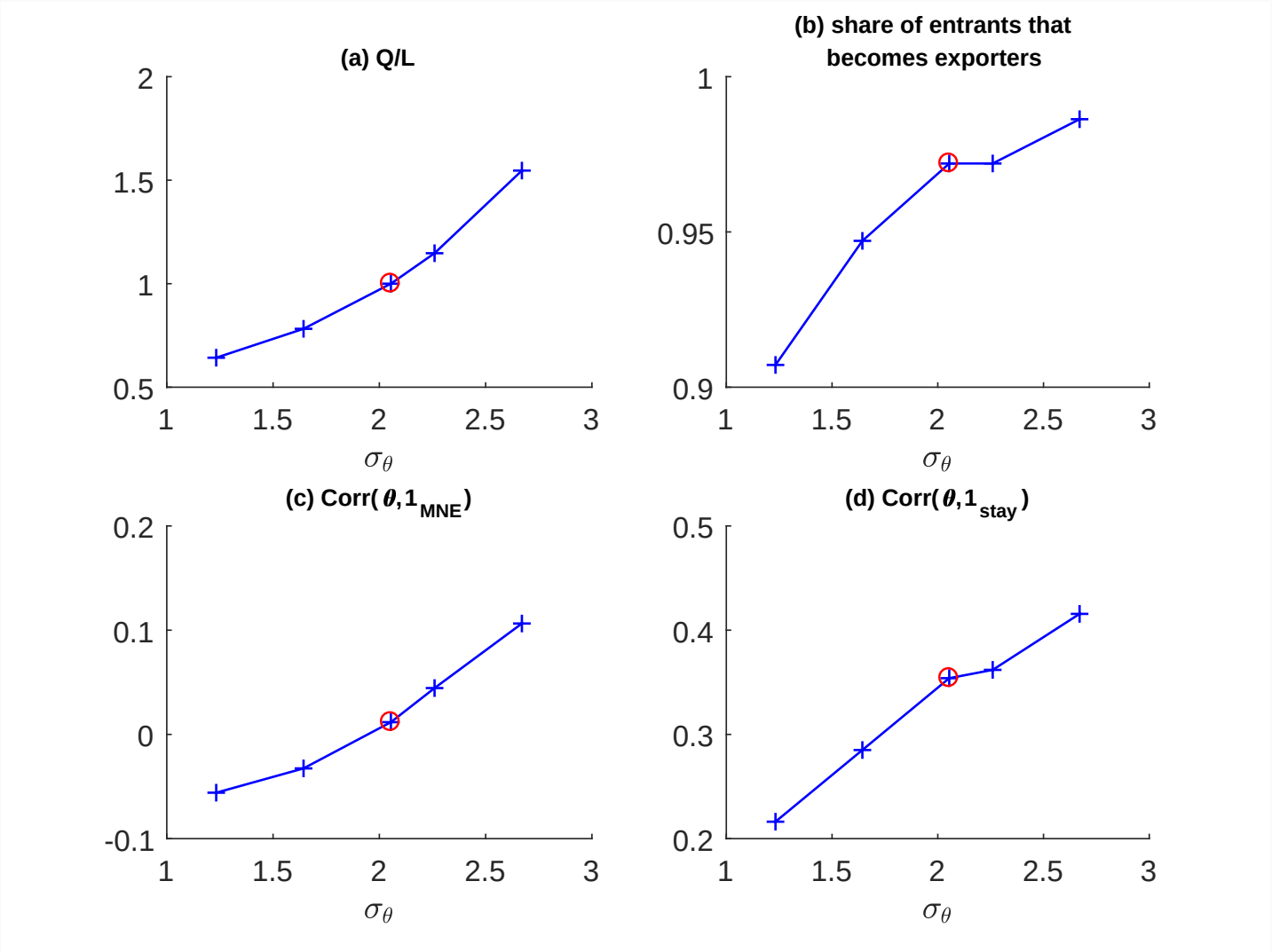
  2. Allocation between operation and exiting: learning is less effective $\Rightarrow$ less information revealed when deciding whether or not to exit.
- *Static allocation*: firm knows its true demand less clearer $\Rightarrow$ firms that receive better draws are less likely to obtain larger market shares.
- Variety effect: love of variety $\Rightarrow$ ideal price index is negatively affected by volatility of shock (against allocation effect!).

Counterfactual: change σ_ε



Counterfactual: change σ_θ



Time-invariant draw and dynamic allocation

- Increase in σ_θ *increases* aggregate productivity and welfare via affecting *dynamic resource allocation* as well.
- Everything is opposite to an increase in σ_ε.

Time-invariant draw and dynamic allocation

- Increase in σ_θ *increases* aggregate productivity and welfare via affecting *dynamic resource allocation* as well.
- Everything is opposite to an increase in σ_ε.
- Key difference from David, Hopenhayn and Venkateswaran (2017) and Senga (2018) in terms of resource allocation effect of uncertainty:
  - Uncertainty and learning work through *extensive* margins such as entry/exit and production mode switching (exporting or MP) and via *dynamic* selection.
  - We retrieve data on firm's forecasts and achieve direct mapping from such data to key parameters of model we build.

Conclusions

- Document three economically meaningful patterns related to firm expectations and export activities.
  - learning and imperfect information
  - key difference between volatility/uncertainty and imperfect information
- Illustrate how variance of permanent (or time-invariant) shock and that of transitory shock affect dynamic trade/MP patterns, aggregate productivity and welfare differently:
  - channel of dynamic resource allocation is key.

Empirical Fact 2: robustness

Table 19: Learning from exporting and firm size

	Dependent Variable: $\lvert FE^{log} \rvert$					
	(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.

◂ Back

Empirical Fact 2: robustness

Table 20: Learning from exporting and horizontal FDI

	Dependent Variable: $\lvert FE^{log} \rvert$					
	Exclude vertical FDI			Exclude affiliated export		
	(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

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. In columns 1-3, we exclude affiliates whose sales share back to Japan is larger than one third in at least one year. In columns 4-6, in addition to excluding vertical FDI, we further refine our measure of exporting experience by excluding intra-firm exports from parent firm to affiliates in a particular continent.

◂ Back

Empirical Fact 2: robustness

Table 21: Learning from Exporting at the continent level

	Dependent Variable: $\lvert FE^{log} \rvert$			
	(1)	(2)	(3)	(4)
$Exp_{-1} > 0$	-0.266**			
	(0.115)			
$Exp_{-1} > 0$ or $Exp_{-2} > 0$		-0.211*		
		(0.119)		
Exp $Expe. > 0$			-0.196	
			(0.127)	
Exp $Expe.$				-0.018
				(0.015)
Industry FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes
N	180	180	218	218
R^2	0.528	0.569	0.515	0.504

Standard errors are clustered at parent firm level, * 0.10 ** 0.05 *** 0.01. We only include affiliates that are first-time entrants into a particular continent.

◂ Back

Distance is positively related to correlation of FEs

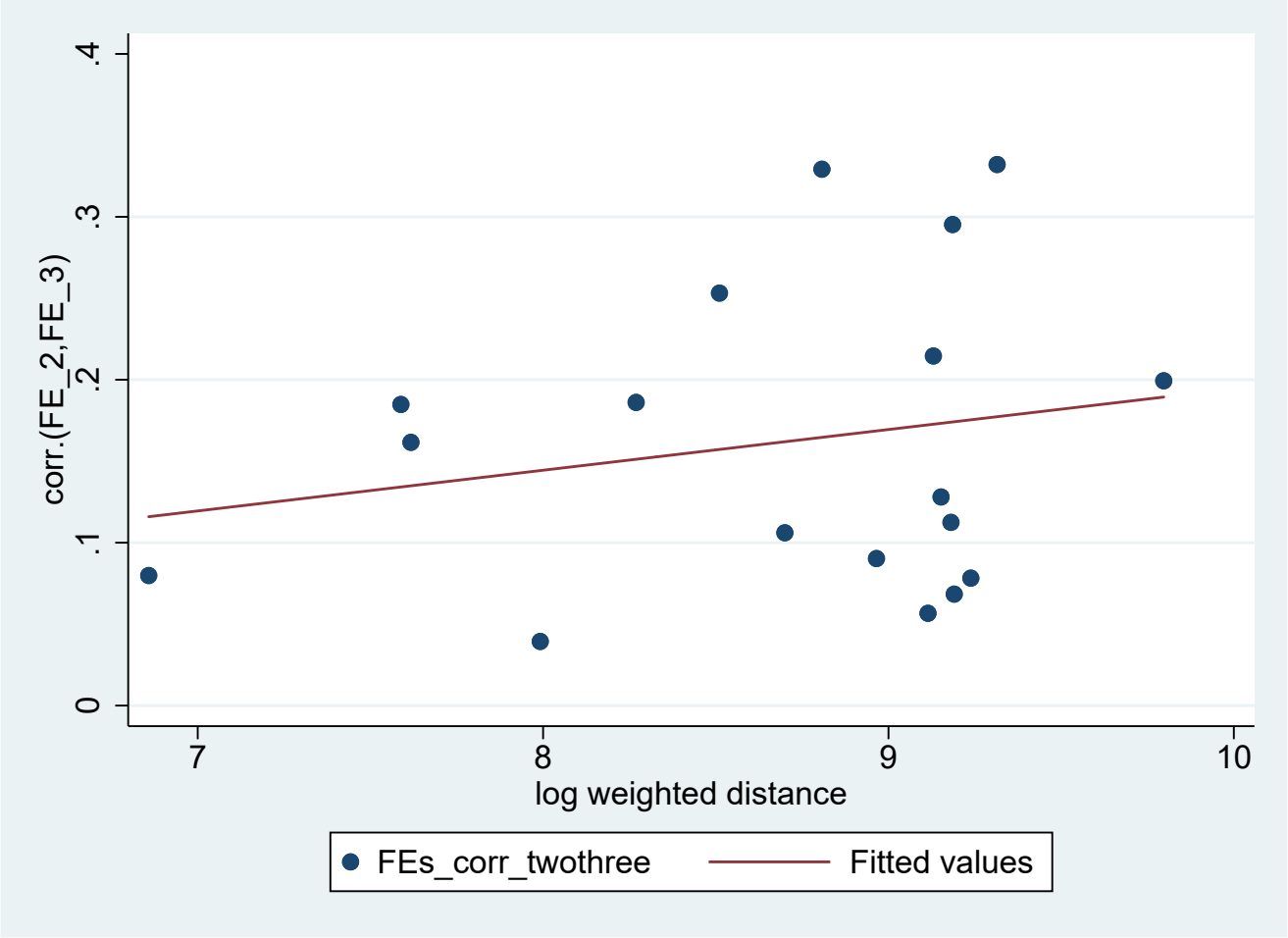
Table 22: Distance from Japan and correlation of FEs of manufacturing MNEs

	Dependent Variable: $Corr(FE_t^{log}, FE_{t+1}^{log})$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(distance)_{weighted}$	0.00949	0.0156**	0.0203***	0.0243***	0.0243**	0.0294***
	(0.00578)	(0.00518)	(0.00516)	(0.00542)	(0.00824)	(0.00733)
$\log(sales)_{sub}$	0.00164	-0.00398*	0.000816	-0.00438*	0.000421	-0.00478*
	(0.00337)	(0.00167)	(0.00397)	(0.00172)	(0.00418)	(0.00182)
cultural distance			-0.00101**	-0.000997**	-0.00104**	-0.00105**
			(0.000312)	(0.000306)	(0.000339)	(0.000313)
religious distance					-0.0278	-0.0360
					(0.0379)	(0.0313)
Type of affiliate	first-time entrants	all	first-time entrants	all	first-time entrants	all
Parent firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
N	103561	159226	87555	136302	82987	129896
R^2	0.149	0.136	0.152	0.138	0.154	0.139

Standard errors are clustered at the destination country level, + 0.10 * 0.05 ** 0.01 *** 0.001. We only include manufacturing and wholesale/retail affiliates whose parent firms in Japan are in manufacturing sectors. $Corr(FE_t^{log}, FE_{t+1}^{log})$ is defined to be 1 if FEs in two two consecutive years have the same sign and -1 otherwise.

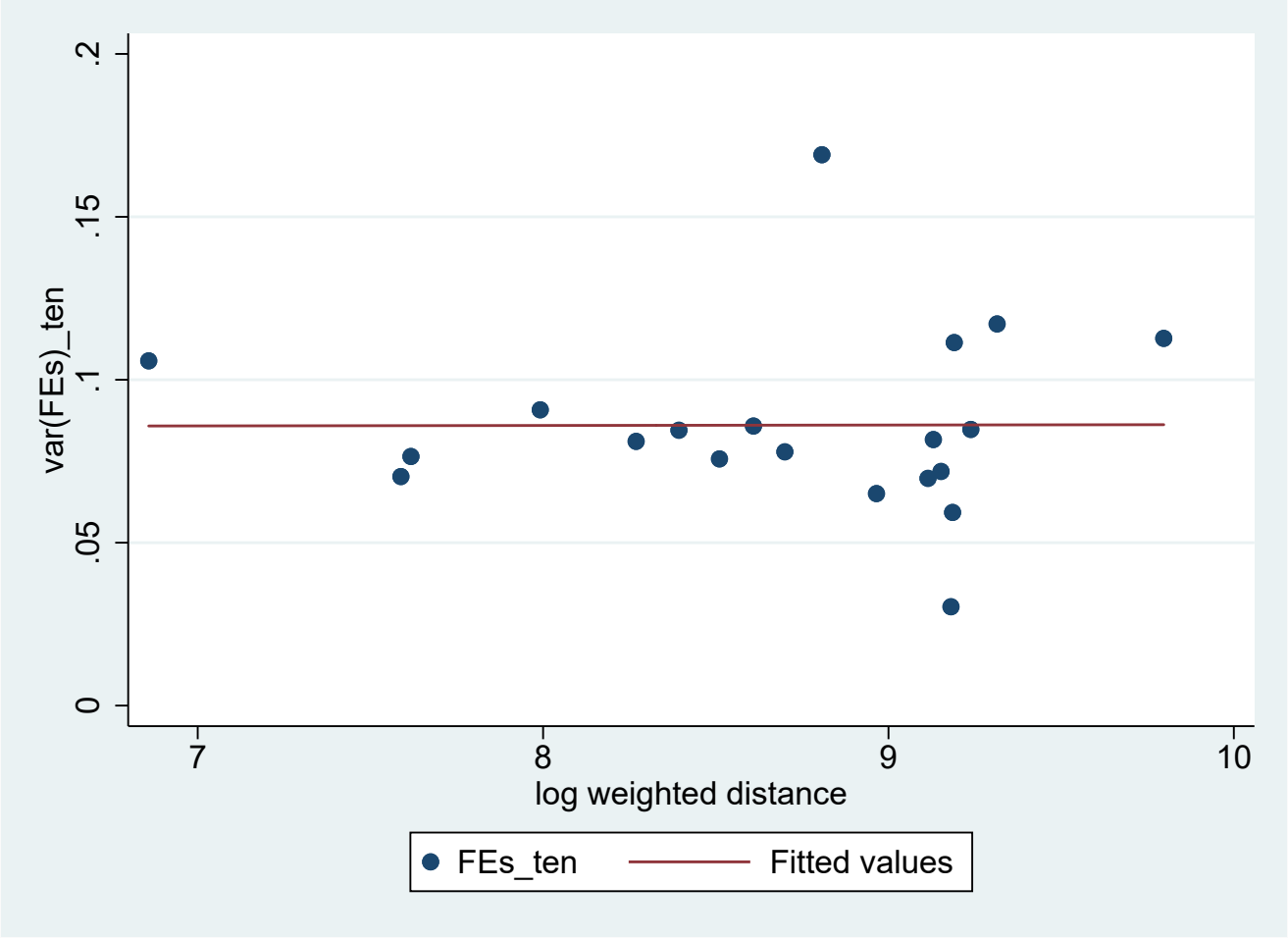
▸ Go back

Distance and information rigidity (all firms)



Go back

σ_ε^2 and distance (all firms)



▸ Go back

Distance is negatively related to initial FEs (just correlartion)

Table 23: Distance from Japan and FEs of manufacturing entrants (age one or two)

	Dependent Variable: $\lvert FE^{log} \rvert$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(distance)_{weighted}$	-0.0227	-0.0155*	-0.0198	-0.0209**	-0.0295	-0.0253**
	(0.0144)	(0.00633)	(0.0193)	(0.00724)	(0.0290)	(0.00841)
$\log(sales)_{sub}$	-0.0777***	-0.0615***	-0.0753***	-0.0586***	-0.0716***	-0.0582***
	(0.0102)	(0.00454)	(0.0105)	(0.00464)	(0.0103)	(0.00475)
cultural distance			0.000354	0.000858**	0.000344	0.000709*
			(0.000841)	(0.000294)	(0.000967)	(0.000325)
religious distance					0.124	0.0801+
					(0.111)	(0.0456)
Type of affiliate	first-time entrants	all	first-time entrants	all	first-time entrants	all
Parent firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2564	5201	2198	4594	2123	4459
R^2	0.660	0.483	0.689	0.502	0.694	0.506

Standard errors are clustered at the destination country level, + 0.10 * 0.05 ** 0.01 *** 0.001.
We only include manufacturing and wholesale/retail affiliates whose parent firms in Japan are in manufacturing sectors.

▸ Go back

Distance is not strongly related to final FEs

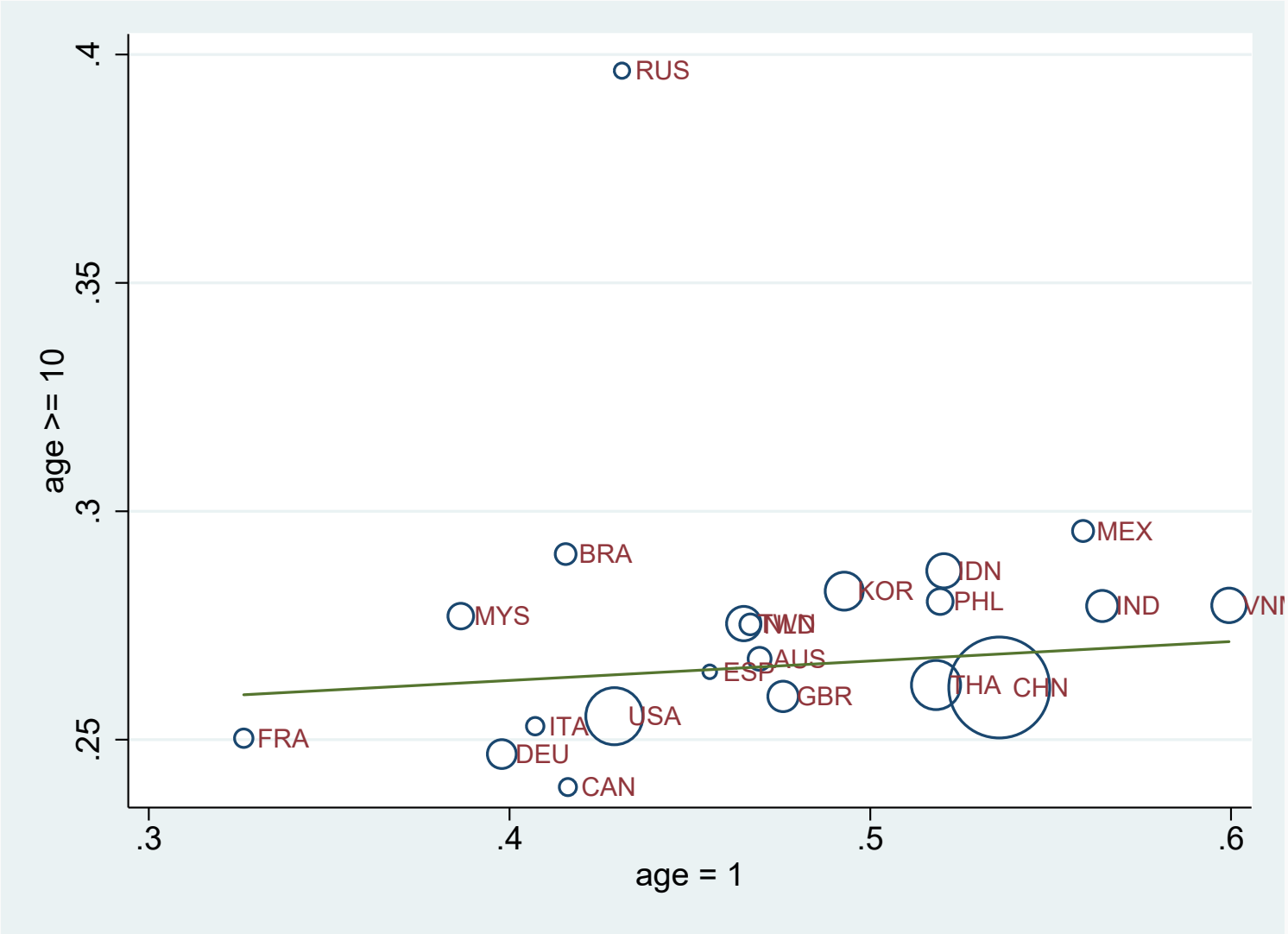
Table 24: Distance from Japan and FEs of manufacturing entrants (age above ten)

	Dependent Variable: $\lvert FE^{log} \rvert$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(distance)_{weighted}$	-0.00431	-0.00314	-0.00557	-0.00537^{+}	-0.00511	-0.00663
	(0.00305)	(0.00322)	(0.00350)	(0.00302)	(0.00461)	(0.00395)
$\log(sales)_{sub}$	-0.0233***	-0.0205***	-0.0226***	-0.0205***	-0.0225***	-0.0206***
	(0.00177)	(0.00122)	(0.00191)	(0.00130)	(0.00203)	(0.00137)
cultural distance			0.000110	0.000155	0.0000992	0.000143
			(0.000141)	(0.000110)	(0.000153)	(0.000131)
religious distance					-0.00159	0.00983
					(0.0143)	(0.0160)
Type of affiliate	first-time entrants	all	first-time entrants	all	first-time entrants	all
Parent firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes	Yes	Yes
N	40750	56390	34044	47229	31857	44423
R^2	0.230	0.197	0.246	0.209	0.250	0.213

Standard errors are clustered at the destination country level, + 0.10 * 0.05 ** 0.01 *** 0.001.
We only include manufacturing and wholesale/retail affiliates whose parent firms in Japan are in manufacturing sectors.

▸ Go back

Heterogeneity in σ_{FE} for young and old firms



Go back

Affiliate age is not related to exit rates

Table 25: Age profile of affiliates' exiting

	Dependent Variable: exit dummy			
	(1)	(2)	(3)	(4)
affiliate age	0.0000382	0.0000312	-0.0000612	-0.0000668
	(0.0000551)	(0.0000562)	(0.0000570)	(0.0000582)
Affiliate type	manuf.+wholesale/retail	manuf.+wholesale/retail	all	all
Affiliate FE	Yes	No	Yes	No
Parent firm FE	No	Yes	No	Yes
Industry-year FE	Yes	Yes	Yes	Yes
Country-year FE	Yes	Yes	Yes	Yes
N	94273	94271	125947	125941
R^2	0.099	0.101	0.107	0.108

Standard errors are clustered at the affiliate level, + 0.10 * 0.05 ** 0.01 *** 0.001. Only first-time entrants into the destination markets are included.

▸ Go back

Export experience is not related to exit rate

Table 26: Export experience and exiting probability of the affiliates

	Dependent Variable: exit dummy	
	(1)	(2)
$Exp_{-1} > 0$	0.00205	0.00222
	(0.0134)	(0.0132)
affiliate age	0.000527	0.000571
	(0.000777)	(0.000771)
One-parent-one-affiliate pairs included?	No	Yes
Parent firm FE	Yes	Yes
Industry-year FE	Yes	Yes
Country-year FE	Yes	Yes
N	6202	7913
R^2	0.223	0.235

Standard errors are clustered at the affiliate level, + 0.10 * 0.05 ** 0.01 *** 0.001. We only include manufacturing and wholesale/retail affiliates whose parent firms in Japan are in manufacturing sectors. Only first-time entrants into the destination markets are included.

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