Factor Intensity, Product Switching, and Productivity: Evidence from Chinese Exporters

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  3. Firm scope (re)-optimization (relatively new idea): firms seek opportunities to specialize in their core competence after exporting.

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  3. Firm scope (re)-optimization (relatively new idea): firms seek opportunities to specialize in their core competence after exporting.
- We study the impact of exporting on TFP through channel (3), using propensity score matching techniques and Chinese firm-level and transaction-level data.

Exporting and TFP

1. Exporting Effects on TFP?
   - Depending on the matching estimators, we find that new exporters are 5.5% to 7.4% more productive (based on revenue-TFP) than matched non-exporting counterparts.
   - Results are all coming from domestic firms .

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   - Results are all coming from domestic firms .
2. Productive firms self-select into exporting?
   - Ans: Yes for domestic exporters; no for FIE.

Exporting and Capital Intensity

For both domestic and foreign firms:

- Ex ante: Within a narrow industry (480 categories), labor-intensive firms are more likely to export.
- Ex post: Exporters become more labor-intensive, compared to the matched non-exporting counterparts. The factor intensity gap is not shrinking over time.

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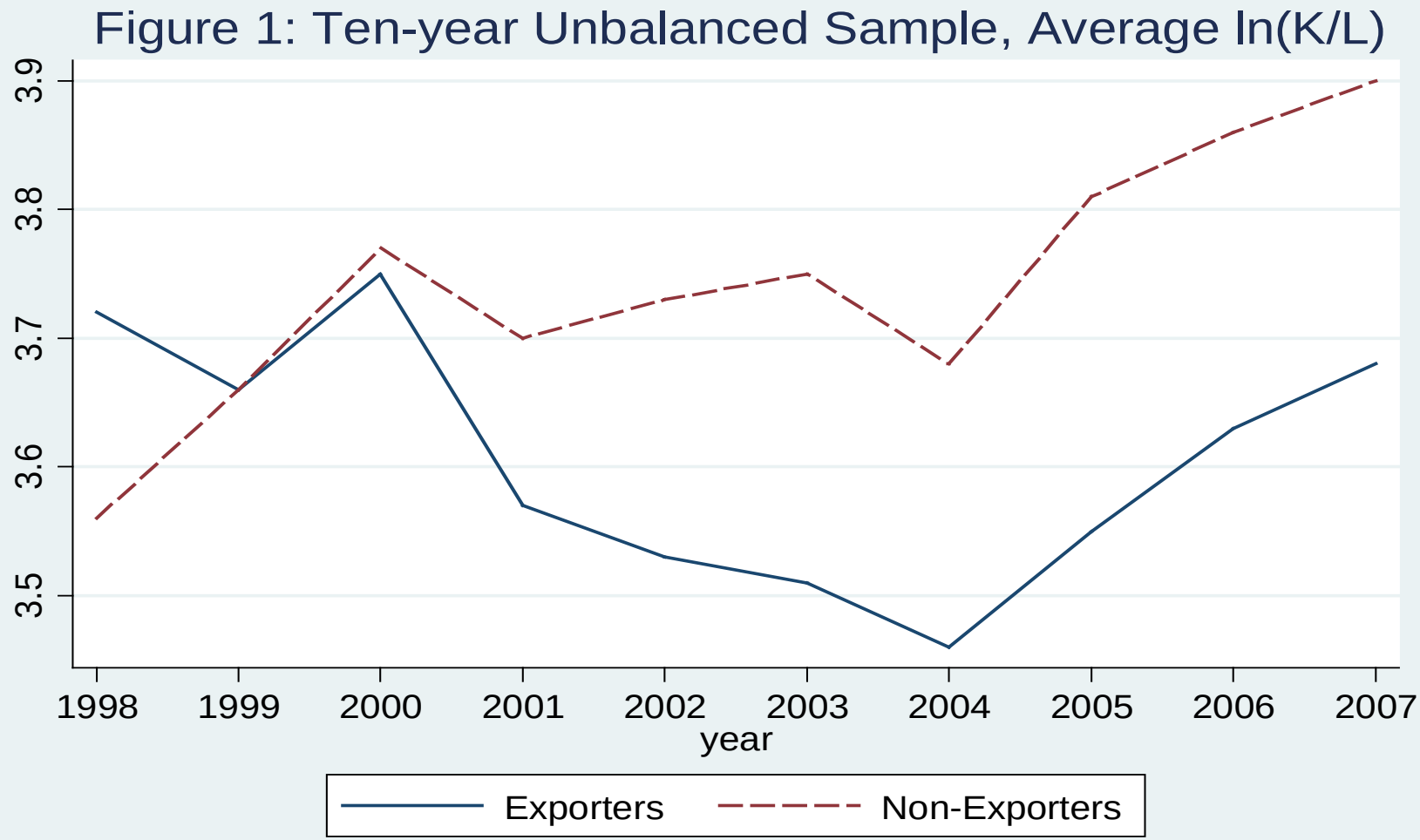
- Provide "mirror-image" evidence consistent with Bernard, Redding, and Schott (2006): US manufacturing firms more exposed to imports from low-income countries become more capital-intensive by switching industries.

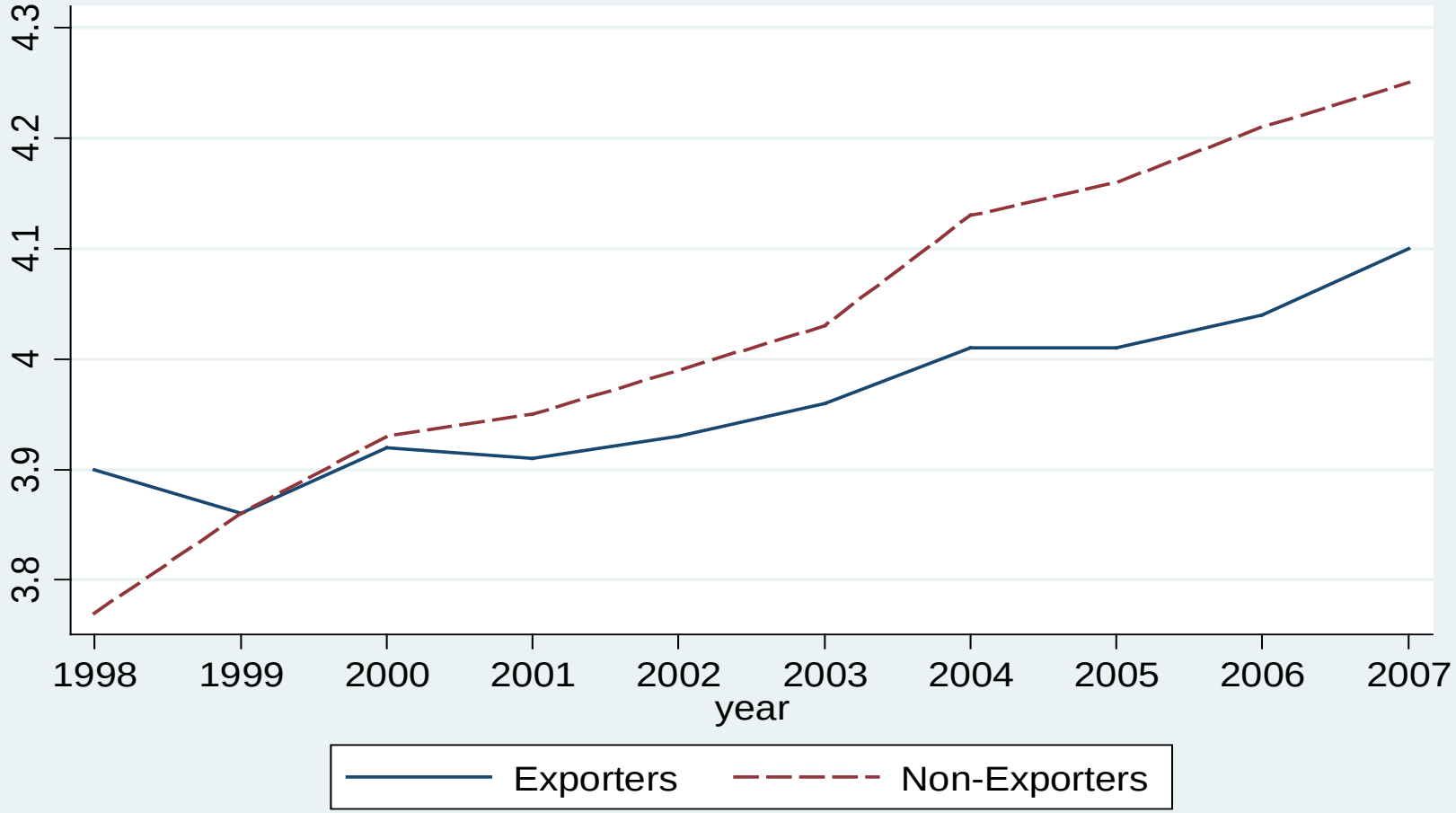
Mean Capital Intensities of Exporters and Non-exporters



Average ln(K/L) is calculated using China's NBS Industrial Survey Data

Mean Capital Intensities of Exporters and Non-exporters

Figure 2: Ten-year Balanced Sample, Average ln(K/L)



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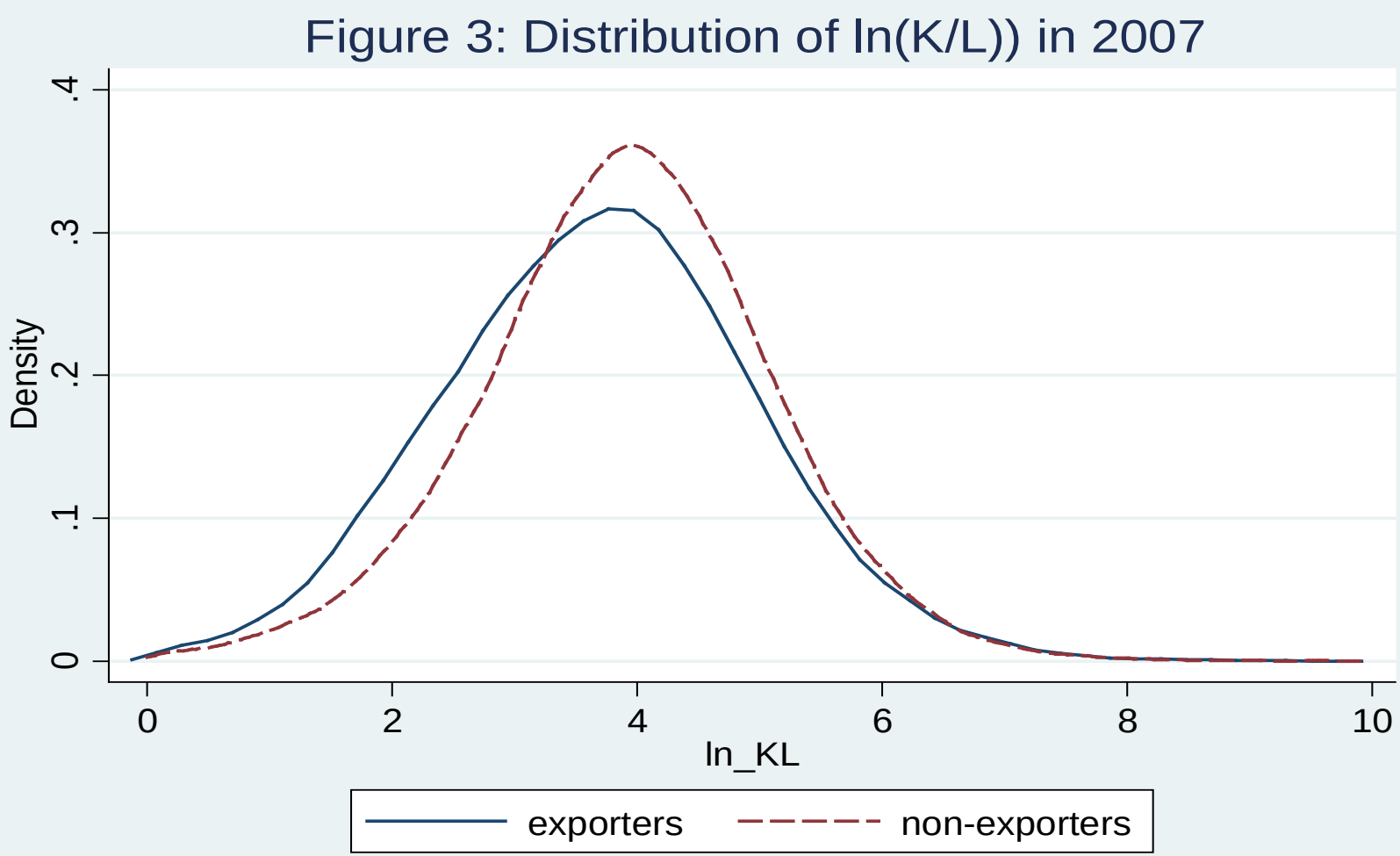
Distribution of Capital Intensity



ln(K/L) are measured relative to the ownership and industry (4-digit) means

Multi-product Firms and Transaction-level Evidence

- Extend the multi-product trade model by Bernard, Redding, and Schott (2010; 2011), with different capital intensity across products.
- Firms draw "consumer taste" attributes and pay extra fixed cost for each additional product line.
- Prediction: Exporters increase sales of and/or add labor-intensive products over time.
- Prediction: A larger increase in the firm's labor intensity after exporting leads to a higher measured TFP increase.
- Supporting evidence using transaction-level (firm-product) trade data.

Related Literature

1. Product diversification is costly; access to foreign markets provides an opportunity to specialize (almost all theory):
   - Feenstra and Ma (2008); Nocke and Yeaple (2008); Eckel and Neary (2010); Bernard, Jensen, and Schott (2010, and forthcoming); Arkolakis and Muendler (2011); Melitz, Mayer, and Ottaviano (2011)

2. Capital/ Skill Intensity of Exporting Firms
   - Bernard and Jensen (1999); Van Biesebroeck (2005); Bernard, Jensen, and Schott (2007); De Loecker (2007); Bustos (2011); Harrigan and Reshef (2011).

Related Literature

3. Self-selection:
   - Bernard, Eaton, Jensen, and Kortum (2003); Melitz (2003)
   - Clerides, Lach, and Tybout (1998) [Colombia, Mexico, Morocco]; Bernard and Jensen (1999) [U.S.] Aw, Chung, and Roberts (2000); Delgado, Farinas, and Ruano (2002) [Taiwan, Korea, and Spain] ...
4. Learning by Exporting:
   - Wagner (2002); Girma, Greenway, and Kneller (2003); Alvarez and Lopez (2005); Van Biesebroeck (2005); De Loecker (2007); Fernandes and Isgut (2008); Lileeva and Trefler (2010); Kraay (1999) finds that exporting improves labor productivity.
   - Park et al. (2010): exposure to the 1997 Asian financial crisis as instrument; find causal impact on productivity, esp. for exporting to developed nations.

Roadmap

1. Data and measures.
2. Firm-level findings about exporting, labor intensity, and productivity.
3. A multi-product trade model with two factors of production.
4. More results at the transaction level.
5. Conclusion

Firm-level Data

- Annual surveys of industrial firms from China's National Bureau of Statistics (NBS), over 1998-2007.
- All state-owned enterprises (SOEs) + all non-SOE with sales over 5 million yuan.
- Account for 94% of total industrial value added in 2007.
- 148,685 firms in 1998 to 313,048 in 2007.

Export Status

- Non-exporters: firms that never exported up to and including the reporting year.
- New exporters are firms that did not export in the previous years but started exporting in the year of analysis.
- Existing exporters are firms that have export records in previous years, or firms that start exporting already in their first year of entry.
- New exporters' pre-export characteristics are used to match similar non-exporters.

Measuring Revenue TFP and Capital Intensity

- Real revenue = revenue deflated by industry-specific ex-factory prices.
- Revenue TFP are estimated using Levinsohn and Petrin (2003) method. Different production functions for exporters/ non-exporters. Results are robust to using the standard approach (e.g. Van Biesebroeck, 2005; De Loecker, 2007).
- 3 measures of ln(K/L)
  1. Capital stock measured using the perpetual inventory method proposed by Brandt, Van Biesebroeck, and Zhang (2011), then divided by the firm's employment.
  2. Net value of fixed asset deflated by the sectoral investment deflator, then divided by employment.
  3. (1) but divided by the firm's total wage bill.

Exporters' Premium in TFP and Capital Intensity

Sample	All Firms	Domestic Private	Foreign	State-owned
Panel A: Dependent variable ln(TFP)				
Exporter	0.087	0.101	0.003	0.091
	[0.000]***	[0.000]***	[0.439]	[0.021]**
Panel B: Dependent variable ln(K/L)				
Exporter	-0.062	-0.082	-0.031	-0.041
	[0.000]***	[0.000]***	[0.000]***	[0.000]***
N	1,976,637	1,063,419	421,561	391,657
Year FE	Yes	Yes	Yes	Yes
Industry (4-digit) FE	Yes	Yes	Yes	Yes
Ownership FE	Yes	No	No	No

Notes: 4-digit industry classification contains 480 industries. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Numbers in brackets are p-values corrected for industry-ownership clustering.

Decision to Start Exporting

Dependent variable = New-exporter indicator

Probit estimation

	Domestic firms	Foreign firms
ln TFP_{t-1}	0.113	0.002
	[0.000]***	[0.314]
Wage $rate_{t-1}$	0.030	0.008
	[0.000]***	[0.298]
$ln(K/L)_{t-1}$	-0.038	-0.031
	[0.000]***	[0.000]***
Age_{t-1}	-0.059	-0.119
	[0.000]***	[0.000]***
$ln(Sales)_{t-1}$	0.113	0.101
	[0.000]***	[0.001]***
Industry FE	Yes	Yes
Provincial FE	Yes	Yes
Year FE	Yes	Yes
Pseudo R-squared	0.103	0.099
Log pseudo-likelihood	-98,745.12	-23,457.83
Observations	1,216,415	150,328

Notes: The dependent variable is an indicator of a firm's first year of exporting. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. All regressions include a full set of industry and provincial dummies. P-values based on standard error clustered at the industry-province level are in brackets.

Matching estimators to evaluate the "exporting" effect

- Using matching estimators to evaluate the average ("exporting") treatment effect on the treated (ATT):

$$\begin{aligned} ATT &= E\left[Y_i^1 - Y_i^0 | Start_i = 1\right] \\ &= E\left[Y_i^1 | Start_i = 1\right] - E_{Z|Start_i=1}\left\{E\left[Y_i^0 | Start_i = 0, Z\right]\right\}, \end{aligned}$$

  where Y_i is firm i's TFP or capital intensity. Matching variables (Z) include all regressors in the previous Probit estimation.

- Among many matching estimators, use Differnece-in-difference estimator by Heckman, Ichimura, and Todd (1997, 1998)

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Exporting Effects on TFP: Matching Estimation Results

Matching Method: DID Matching			
All New Exporters	Domestic Private	Foreign	All
Dependent variable = ln(TFP)			
0.071	0.082	0.004	
[0.003]***	[0.003]***	[0.491]	
Dependent variable = ln(K/L)			
			ln(K/wL)
-0.061	-0.063	-0.051	-0.093
[0.018]**	[0.038]**	[0.063]*	[0.000]***

Notes: ln(TFP) is estimated using LP (2003) method. P-values are reported in brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. ▸ Matching equations ▸ More results on TFP ▸ More results on ln(K/L)

Over-time Effects on Capital Intensity

Over-time Relative Change in Exporters' Capital Intensity: DID Matching Estimation

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
1999	-0.086	-0.132	-0.149	-0.171	-0.178	-0.182	-0.185	-0.186	-0.184
	[0.054]*	[0.028]**	[0.034]**	[0.041]**	[0.048]**	[0.052]*	[0.047]**	[0.064]*	[0.069]*
2000	-0.054	-0.085	-0.105	-0.123	-0.133	-0.140	-0.143	-0.147	
	[0.049]*	[0.027]**	[0.029]**	[0.034]**	[0.043]**	[0.045]**	[0.054]*	[0.059]*	
2001	-0.053	-0.102	-0.124	-0.141	-0.149	-0.155	-0.157		
	[0.021]**	[0.019]**	[0.033]**	[0.037]**	[0.049]**	[0.051]*	[0.058]*		
2002	-0.014	-0.062	-0.075	-0.081	-0.090	-0.096			
	[0.352]	[0.041]**	[0.034]**	[0.046]**	[0.052]*	[0.063]*			
2003	-0.054	-0.085	-0.097	-0.107	-0.116				
	[0.019]**	[0.022]**	[0.025]**	[0.034]**	[0.037]**				
2004	-0.077	-0.090	-0.105	-0.113					
	[0.023]**	[0.031]**	[0.036]**	[0.037]**					
2005	-0.052	-0.086	-0.101						
	[0.032]**	[0.027]**	[0.036]**						
2006	-0.063	-0.091							
	[0.009]***	[0.011]**							
2007	-0.074								
	[0.005]**								
Pooled	-0.062	-0.092	-0.108	-0.122	-0.133	-0.143	-0.159	-0.167	-0.184
	[0.019]**	[0.021]**	[0.027]**	[0.28]**	[0.031]**	[0.034]**	[0.041]**	[0.045]**	[0.069]*

Notes: Firms are matched using the propensity score matching estimation. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. P-values based on bootstrapped standard errors are reported in brackets. "Marginal change" refers to the change of ln(K/L) estimated from balanced sample.

Model Features

- A variant of the multi-product model by Bernard, Redding, and Schott (2010; 2011), with different capital intensity across products.
- A firm's profitability of selling a product in a market depends on a firm-specific productivity draw (Melitz, 2003), and a firm-product-specific "consumer taste" attribute.
- There are country-specific fixed export cost and product-specific fixed cost for each product produced (e.g. overhead costs to maintain a sales team for each product).

Preferences

- Country j has a mass of L_j consumers with identical preferences; each endowed with $\frac{K_j}{L_j}$ amount of capital
- Consumers consume a continuum of products, and derive utility $U = \left[\int_0^1 C_s^{\nu} ds\right]^{\frac{1}{\nu}}$
- elasticity of subst. $= \kappa = \frac{1}{1-\nu} > 1$.

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- elasticity of subst. $= \kappa = \frac{1}{1-\nu} > 1$.
- Within each product, firms produce horizontally differentiated varieties.

$$C_s = \left[\int_{\omega \in \Omega_s} \left(\lambda_i(\omega) c_s(\omega)\right)^{\rho}\right]^{\frac{1}{\rho}}, \ 0 < \rho < 1,$$

where elasticity of subst. $\sigma = \frac{1}{1-\rho} > \kappa > 1$.

Technology

- Product-specific fixed cost f_s for each product produced.
- Two factors of production – capital and labor; a firm's cost function:

$$TC_s = \left[f_s + \frac{q_s}{\varphi} \right] w^{1-\beta(s)} r^{\beta(s)},$$

where w and r are the wage rate and the rental rate, respectively; $\beta(0) = 0$, $\beta(1) = 1$, and $\beta'(s) > 0$.

Consumer Taste Cutoffs

- Zero profit condition for selling a product

$$\pi_s\left(\varphi, \lambda_s^*\left(\varphi\right)\right) = \frac{R_s}{\sigma}\left(\rho P\left(s\right)\varphi\lambda_s^*\left(\varphi\right)\right)^{\sigma-1} - f_s w^{1-\beta(s)} r^{\beta(s)} = 0$$

- Domestic "consumer taste "cutoff

$$\lambda_s^*\left(\varphi\right) \propto \frac{P\left(s\right)^{-\gamma}}{\varphi}\left(\frac{f_s \widehat{P}}{R} w^{1-\beta(s)} r^{\beta(s)}\right)^{\frac{1}{\sigma-1}},$$

where γ is a parameter in terms of elasticities of subst.

- Foreign "consumer taste "cutoff

$$\lambda_{sj}^*\left(\varphi\right) \propto \frac{\tau_j P_j\left(s\right)^{-\gamma}}{\varphi}\left(\frac{f_{sj} \widehat{P}_j}{R_j} w^{1-\beta(s)} r^{\beta(s)}\right)^{\frac{1}{\sigma-1}}$$

The Ratio of Cutoffs

- Denote $\widetilde{\lambda}_j(s) = \frac{\lambda^*_{sj}(\varphi)}{\lambda^*_s(\varphi)}$

$$\widetilde{\lambda}_j(s) = \left(\frac{P_j(s)}{P(s)}\right)^{-\gamma} \Lambda_j$$

where Λ_j is a country-specific "resistance" to imports, independent of product s's factor intensity.

- If country j is more capital-abundant than China, $\frac{P_j(s)}{P(s)}$ is decreasing in s. $\widetilde{\lambda}'_j(s) > 0$.
- Lu (2011).

Impact of exporting on capital intensity

- Denote product s's capital intensity as the capital cost share: $\theta_s = \frac{rk_s}{rk_s + wl_s}$
- Capital intensity of the domestic and exported baskets:

$$\Theta_d(\varphi) = \int_0^1 \frac{R_s(\varphi, \lambda_s)}{R(\varphi)} \theta_s I_s(\lambda_s \geq \lambda_s^*(\varphi)) \, di,$$

$$\Theta_j(\varphi) = \int_0^1 \frac{R_{sj}(\varphi, \lambda_s)}{R_j(\varphi)} \theta_s I_s(\lambda_s \geq \Phi_j(s) \lambda_s^*(\varphi)) \, ds,$$

- After exporting, a firm's capital intensity:

$$\Theta_{d+j}(\varphi) = d_j(\varphi) \Theta_d(\varphi) + (1 - d_j(\varphi)) \Theta_j(\varphi),$$

where $d_j(\varphi) = \frac{R(\varphi)}{R(\varphi) + R_j(\varphi)}$

- Since $\widetilde{\lambda}_j(s)$ is increasing in s, $\Theta_j(\varphi) < \Theta_d(\varphi)$

Predictions

Hypothesis

The firm's overall capital intensity $\Theta_{d+j}(\varphi)$ after a firm's exporting to a capital-abundant country satisfies the following inequality:

$$\Theta_j(\varphi) < \Theta_{d+j}(\varphi) < \Theta_d(\varphi),$$

where $\Theta_d(\varphi)$ and $\Theta_j(\varphi)$ are the capital intensities of the domestic and foreign baskets of products, respectively.

Hypothesis

A larger productivity shock that triggers exporting is associated with a smaller decline in capital intensity $\Theta_{d+j}(\varphi)$ after exporting. Formally,

$$\frac{\Theta_{d+j}(\varphi)}{\Theta_d(\varphi)} < \frac{\Theta_{d+j}(\varphi')}{\Theta_d(\varphi')} < 1 \quad \text{if } \varphi' > \varphi.$$

Determinants of the Change in Capital Intensity

Dependent variable = Reduction in ln(K/L) relative to the matched group			
	All New Exporters	Domestic New Exporters	Foreign New Exporters
$\ln(TFP)_{t-1}$	-0.059	-0.052	-0.081
	[0.003]***	[0.005]***	[0.008]**
$\ln(wage\_rate)_{t-1}$	-0.145	-0.155	-0.131
	[0.000]***	[0.000]***	[0.034]**
$\ln(sales)_{t-1}$	0.110	0.139	0.141
	[0.000]***	[0.000]***	[0.000]***
$\ln(age)_{t-1}$	-0.056	-0.020	-0.006
	[0.017]**	[0.052]*	[0.341]
$\ln(K/L)_{t-1}$	0.765	0.829	0.714
	[0.000]***	[0.000]***	[0.000]***
Ownership FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Provincial FE	Yes	Yes	Yes
N	50,231	33,645	16,586

Notes: P-values, based on standard errors clustered at the four-digit industry level, are in brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. All regressors are lagged one period.

Transaction-level Trade Data

- Transaction-level (firm-product-country-year) trade data, over the universe of Chinese exporters and importers over 2000-2006.
- Information on import, export values, and quantities from China to 200 destination countries at the HS 6-digit level.
- We merge the NBS data with the transaction-level trade data based on firm names and contact information (phone number, area code).
- 70% of exporters recorded in NBS is merged.

Product Churning

	Nb. of new exporters	Nb. survived next year	Avg. nb. of products added next year	Avg. nb. of products dropped	Avg. nb. of continuing products
2002	21,383				
2003	27,107	22,941	10.02	5.58	5.48
2004	37,646	31,583	10.22	6.56	5.13
2005	40,024	33,552	9.29	7.92	4.97
2006	46,400				

Capital Intensities Across Products

Sector	HS 2-digit	Nb. of HS 6-digits	ln(K/L) Mean	ln(K/L) Std. Dev.
Animals & Animal Products	01-05	174	70.9	56.9
Vegetable Products	06-14	254	71.8	61.1
Animal Or Vegetable Fats	15	35	64.9	63.3
Prepared Foodstuffs	16-24	173	94.6	69.0
Mineral Products	25-27	134	90.1	70.9
Chemical Products	28-38	764	111.6	66.5
Plastics & Rubber	39-40	198	79.6	65.2
Hides & Skins	41-43	62	45.5	47.0
Wood & Wood Products	44-46	75	62.3	56.5
Wood Pulp Products	47-49	147	93.7	66.8
Textiles & Textile Articles	50-63	818	68.1	54.9
Footwear, Headgear	64-67	55	27.8	43.0
Articles Of Stone, Plaster, Cement, Asbestos	68-70	147	72.2	64.9
Pearls, Precious Or Semi-Precious Stones, Metals	71	41	32.1	59.5
Base Metals & Articles Thereof	72-83	563	93.9	63.5
Machinery & Mechanical Appliances	84-85	792	99.2	63.9
Transportation Equipment	86-89	121	107.2	66.8
Instruments - Measuring, Musical	90-92	235	99.6	62.8
Arms & Ammunition	93	10	152.4	69.9
Miscellaneous	94-96	130	47.8	51.5
Works Of Art	97-99	9	30.7	53.2

Capital Intensity of New, Dropped, and Continuing Products

$$\ln(K/L)_{ik} = \alpha + \beta * new\_product_{ik} + \delta * dropped\_product_{ik} + e_i$$

Dependent Variable = ln(K/L) at firm-product cell			
	All (New) Exporters	Ordinary Exporters	Processing Traders
New Product Portfolio Dummy	-0.049	-0.050	-0.048
	[0.000]***	[0.000]***	[0.000]***
Dropped Product Portfolio Dummy	0.021	0.024	0.013
	[0.000]***	[0.000]***	[0.005]***
Year FE	Yes	Yes	Yes
N	343,062	257,295	85,767

Notes: This table reports the results of regressions of capital intensity on new product portfolio and dropped product portfolio dummies.

The omitted category is the continued product portfolio. P-values in brackets.

Exporting Effects on Measured Productivity

- Product-specific productivity, $\mu_s = R(\varphi, \lambda_s) / x_s(\varphi, \lambda_s)$:

$$\text{Domestic:} \quad \mu_s = \frac{w^{1-\beta(s)} r^{\beta(s)}}{\rho} \left(1 - \frac{f_s}{x_s(\varphi, \lambda_s)}\right);$$

$$\text{Exports:} \quad \mu_{sj} = \frac{\tau_j w^{1-\beta(s)} r^{\beta(s)}}{\rho} \left(1 - \frac{f_{sj}}{x_{sj}(\varphi, \lambda_s)}\right)$$

- $\mu_{sj} > \mu_s$ if $\frac{f_{sj}}{f_s} < \left(\frac{P_j(s)}{P(s)}\right)^{\gamma} \Psi_j$ and $\tau_j = 1$ (for simplicity)

$$\begin{aligned} \widehat{TFP}_j(\varphi) &= d_j(\varphi) \int_0^1 \mu_s \frac{R_s(\varphi, \lambda_s)}{R(\varphi)} ds \\ &\quad + (1 - d_j(\varphi)) \int_0^1 \mu_{sj} \frac{R_{sj}(\varphi, \lambda_s)}{R_j(\varphi)} ds, \end{aligned}$$

where $d_j(\varphi) = \frac{R(\varphi)}{R(\varphi) + R_j(\varphi)}$.

Product Churning Effects on TFP

	Dependent Variable = TFP gain after exporting		
	All New Exporters	Domestic New Exporters	Foreign New Exporters
$labor\_intensity\_gain_{t-1,t}$	0.071	0.071	0.067
	[0.000]***	[0.000]***	[0.002]***
$\ln(wage\_rate)_{t-1}$	0.154	0.184	0.169
	[0.000]***	[0.001]***	[0.002]***
$\ln(sales)_{t-1}$	0.141	0.121	0.158
	[0.000]***	[0.000]***	[0.000]***
$\ln(age)_{t-1}$	-0.089	-0.094	-0.084
	[0.009]***	[0.011]***	[0.038]**
Industry FE	Yes	Yes	Yes
Ownership FE	Yes	No	No
Provincial FE	Yes	Yes	Yes
N	50,245	33,645	16,600

Notes: P-values are based on standard errors clustered at the four-digit industry level. All regressors are lagged one period besides labor productivity gain.

Concluding Remarks

- Within a narrow industry, firms become less K-intensive (about 6%) after exporting relative to the matched non-exporters. The gap is not shrinking over time.
- Chinese exporters add new products that are more L-intensive and drop those that are less.
- Preliminary results show larger measured productivity gain due to more specialization in labor-intensive products.
- Research direction: Product churning and TFP estimation

Exporting Effects on TFP: Matching Estimation Results

Dependent variable = ln(TFP)		
All New Exporters	Domestic Private	Foreign
Local Linear Regression Matching		
0.069	0.071	0.002
[0.004]***	[0.006]***	[0.674]
Nearest Neighbor Matching		
0.054	0.056	-0.005
[0.002]***	[0.010]***	[0.418]

Notes: ln(TFP) is estimated using LP (2003) method. P-values are reported in brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Back

Exporting Effects on Capital Intensity

Dependent variable = ln(K/L)			
All New Exporters	Domestic New Exp.	Foreign New Exp.	All New Exp.; ln(K/wL)
Local Linear Regression Matching			
-0.048	-0.047	-0.042	-0.081
[0.015]**	[0.028]**	[0.037]**	[0.007]***
Nearest Neighbor Matching			
-0.062	-0.075	-0.040	-0.103
[0.016]**	[0.020]**	[0.025]**	[0.014]**

Notes: Capital stock is measured by the perpetual inventory method. P-values are reported in brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

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