R&D, Technology Transfer, and the Sophistication of China's Exports

日本国際経済学会・関西支部研究会
2011年1月29日
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Outline

- Introduction
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- Decomposition of new products export
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- Concluding remarks

Introduction-1

- China's exports has grown rapidly in last two decades. Recent studies highlight the increasing sophistication of China's exports.

- The sophistication means that Chinese exports show apparent similarity to exports by high-income countries.

- Rodrik (2006)

  Export sophistication is strongly correlated with per-capita income. But China exports more sophisticated goods than what its income level could explain.

- Scott (2008)

  China's export structure is much similar with that of OECD countries. China exports the low-end product varieties and the unit values are much lower than those of high-income countries.

Introduction-2

- Xu and Lu (2009):

  The export sophistication of Chinese industries are positively related to wholly foreign owned enterprises from OECD countries and the share of processing exports by foreign invested enterprises.

- Amiti and Freund (2010)

  The sophistication of export is mainly due to processing trade (the increased skill content of imported inputs that are assembled for export).

- Wang and Wei (2010)

  Improvement in human capital (measured by either gross metropolitan product per capita or college student enrollment) and government policies in the form of tax-favored high-tech zones have been key determinants of China's export sophistication.

This Paper

- Examines the relationship between R&D investment and the sophistication of China's exports at industry-level.
- Uses *new products export to export share* as proxy for export sophistication.
- The Definition of "New Products":

  A novel product made by new technology or design (product innovation) or an improved product with process improvement or quality upgrading (process innovation)

Main Findings

- R&D investment accounts for the new products export and rising sophistication of China's exports.

- Complementary to R&D investment, foreign technology transfer also has positive effects on the increased export sophistication.

Data

- Large and Medium-size Industrial Enterprises (LMEs):
  employees>=300 &
  sales>=30 million Yuan &
  gross assets>=40 million Yuan

- 29 two-digit manufacturing industries (excluding Recycling & Disposal of Waste)
- 2001~2008, panel data

- *China Industry Economy Statistical Yearbook*
- *Statistics on Science and Technology Activities of Industrial Enterprises*
- *China Statistical Yearbook on Science and Technology*

Figure 1. Innovation and Export Indicators of LMEs

(Innovation for overseas market: New Products Export/New Products Sales; Sophistication of exports: New Products Export/Export)

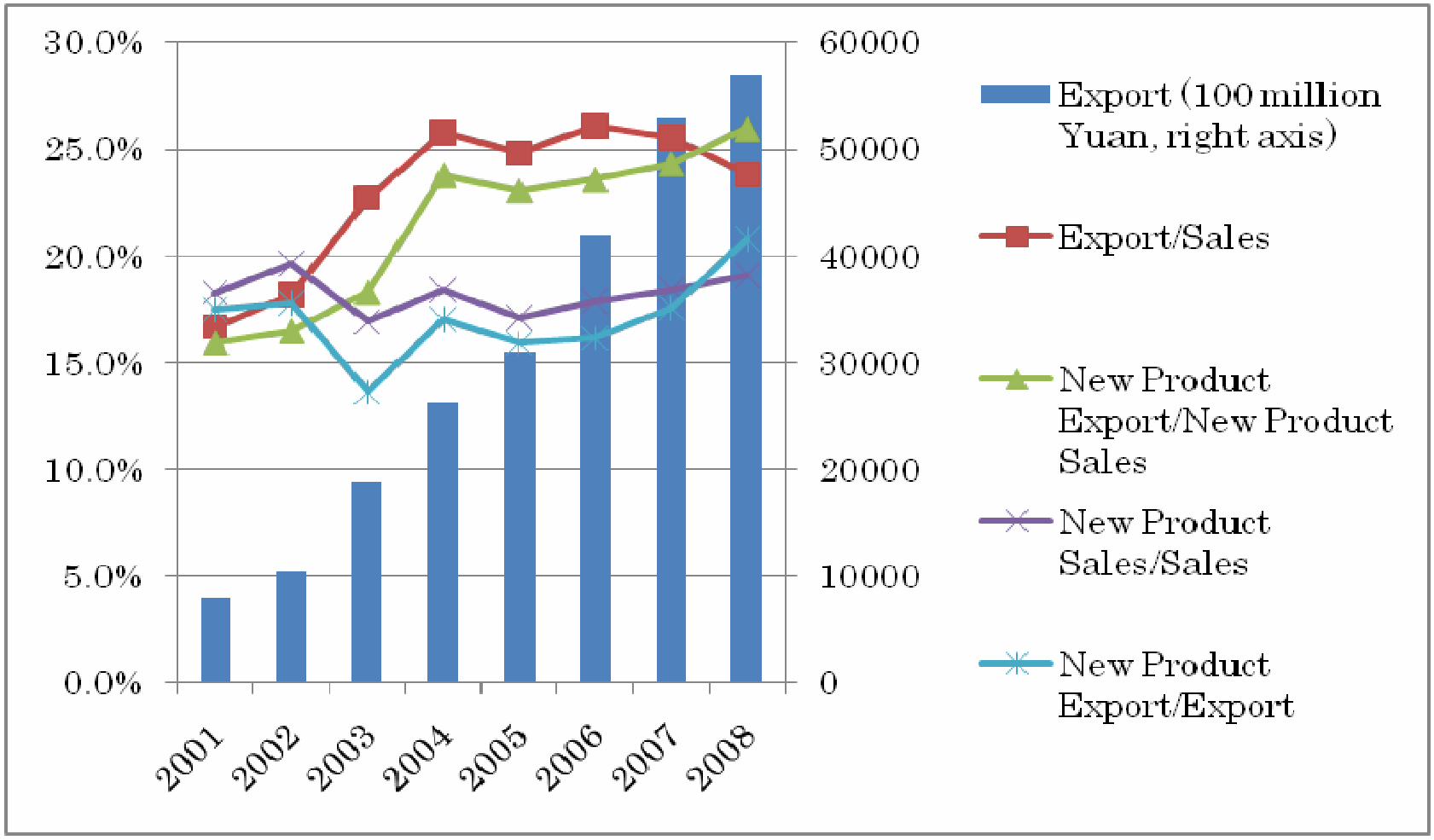


Figure 2. R&D investment of LMEs
(Notes: HMT=Foreign Invested Enterprises (FIEs) from Hong Kong, Macao and Taiwan; Non-HMT=FIEs from OECD; SOEs=State-owned enterprises; Non-SOEs=Other indigenous enterprises)

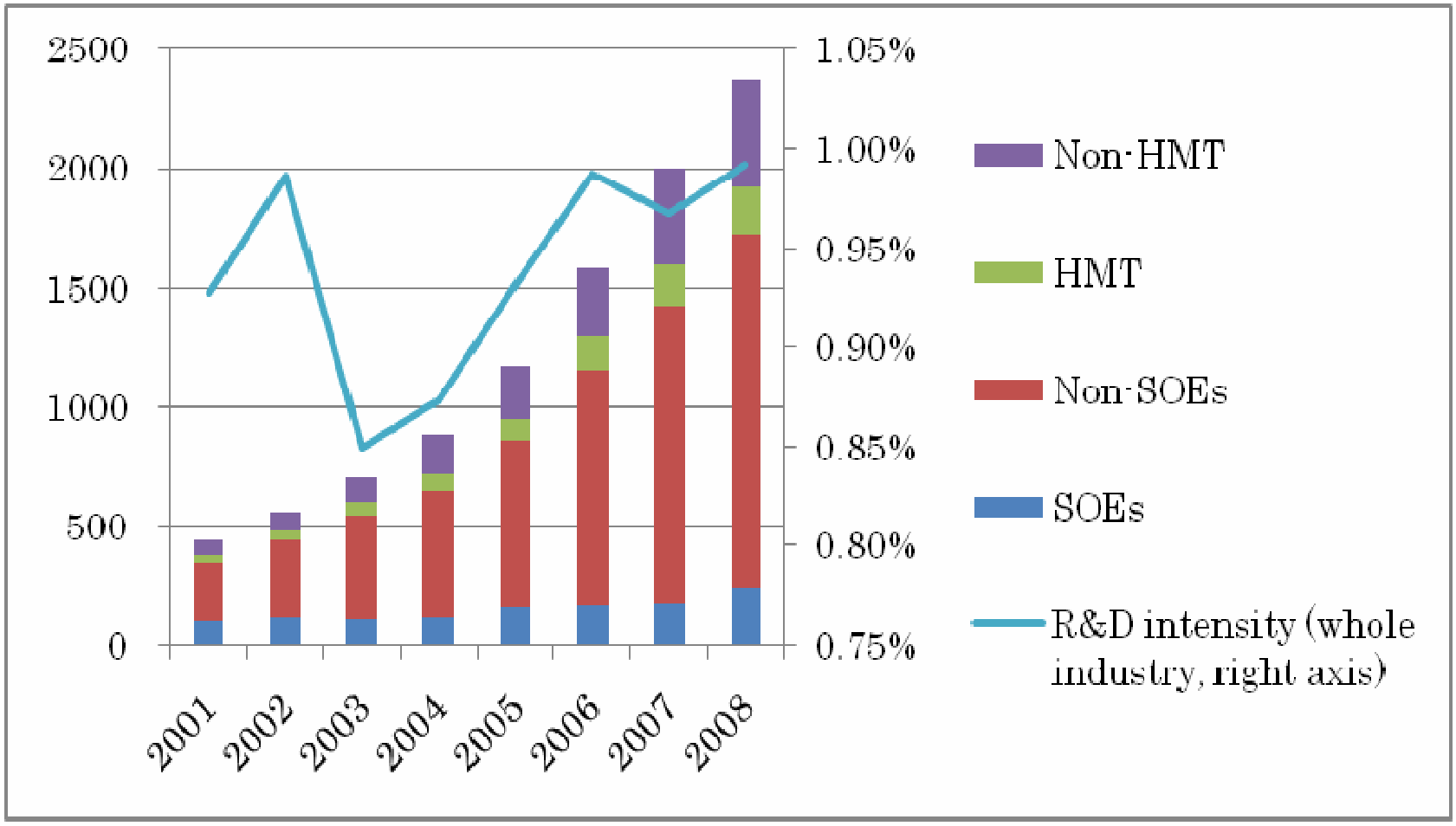


Figure 3. R&D Investment and Export

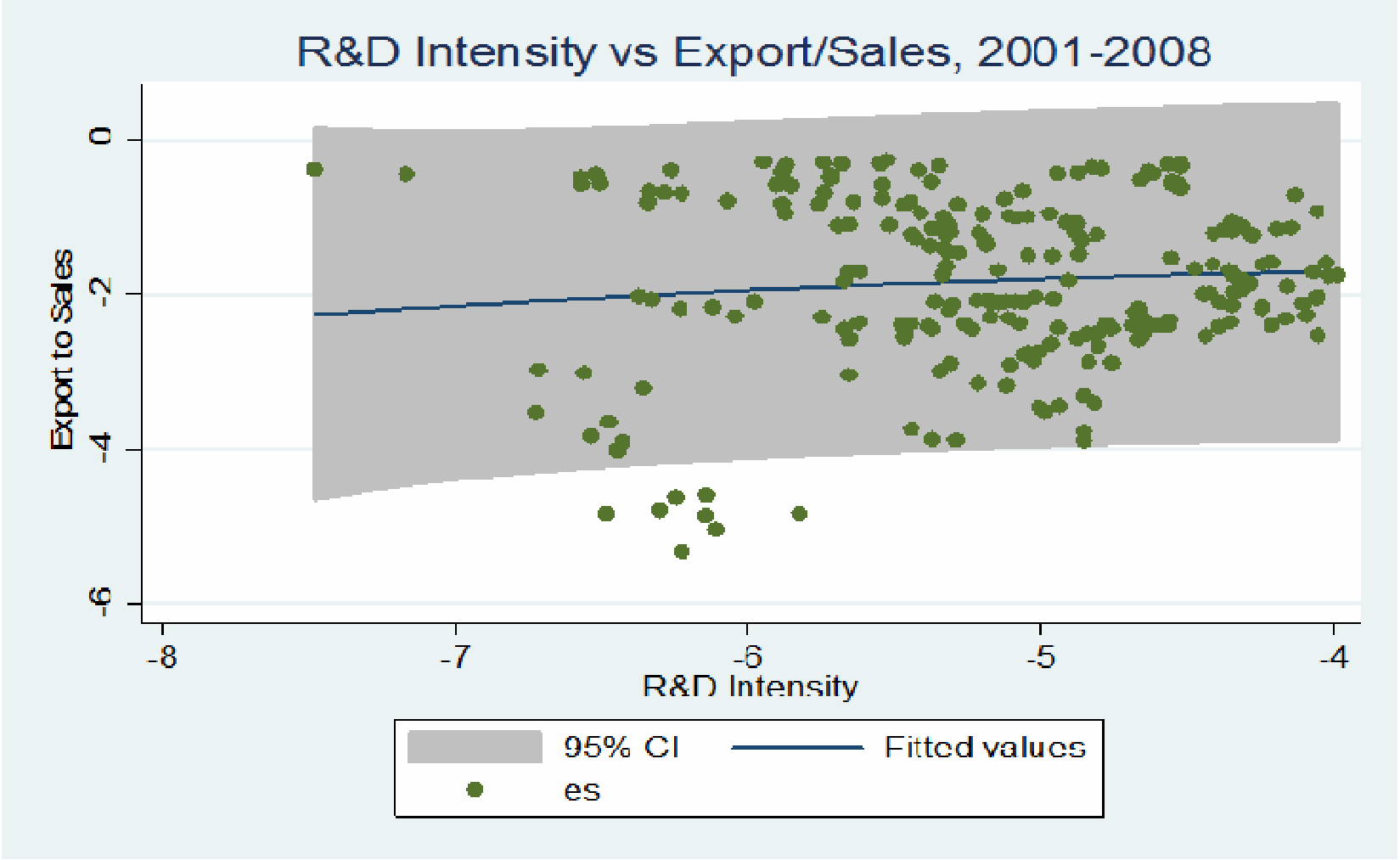
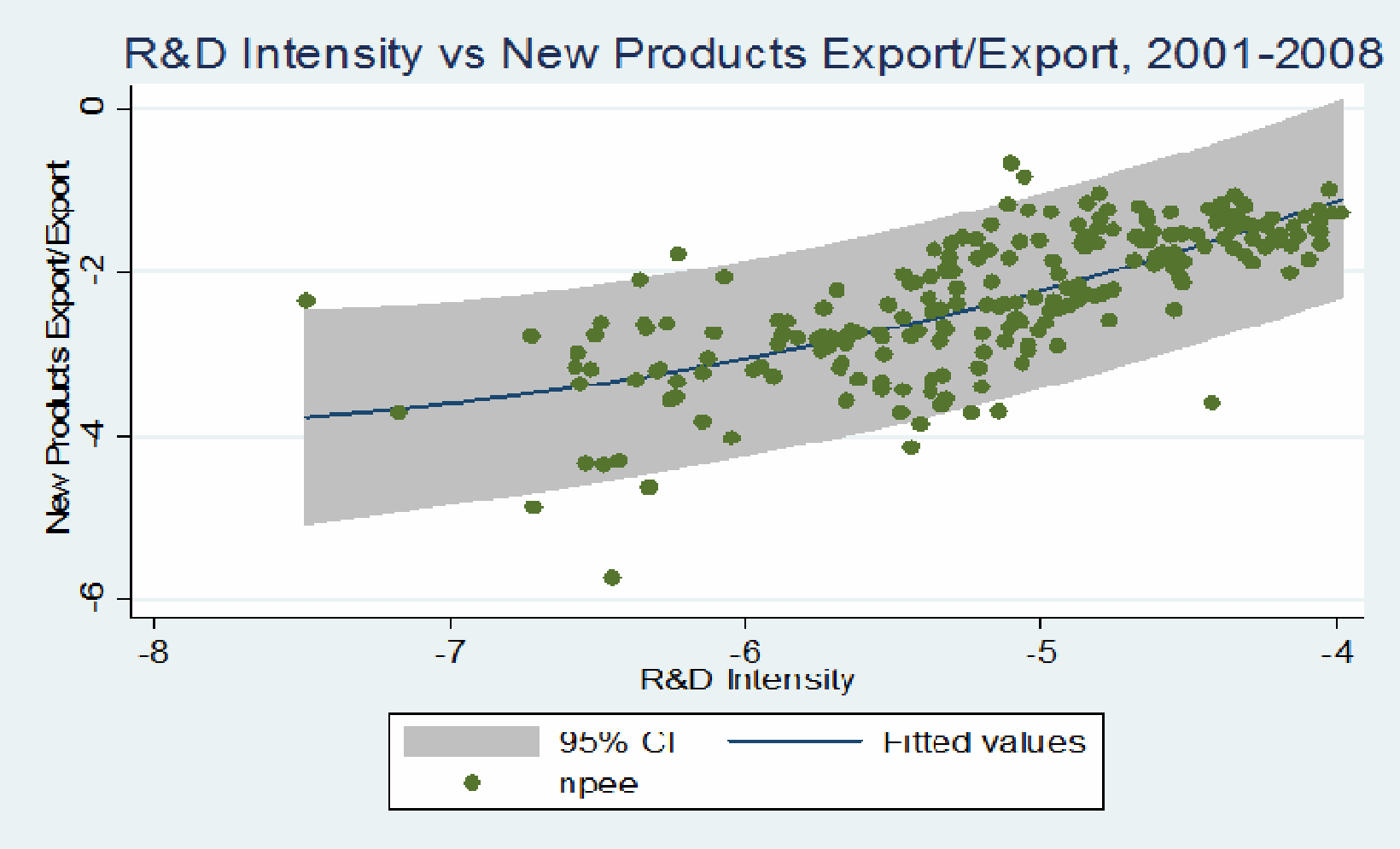


Figure 4. R&D Investment and New Products Export



Differences across Industries
(foreign capital intensity=foreign capital /total received capitals)

Table 1. Innovation and Export Indicators by Foreign Capital Intensity Quantile

Foreign Capital-Intensity Quantile	Foreign Capital Percentiles	New Products Sales /Sales	New Products Export /New Products Sales	Export/Sales	New Products Export /Export
1	23.1	13.6	10.3	8.5	15.6
2	33.9	15.2	19.1	18.0	16.9
3	47.5	13.3	18.5	23.7	11.6
4	78.0	12.6	39.7	53.2	9.5
Total	35.9	13.7	21.8	25.8	13.4

Note: All indicators are in percentage.

Sources: Author's calculations based on data from *China Industry Economy Statistical Yearbook* and *Statistics on Science and Technology Activities of Industrial Enterprises*, various years.

Decomposition of New Products Export

(X=export, N=new products, i=industry, t=year)

- (1)

$$\frac{X_{it}^{N}}{X_{t}} = \frac{X_{it}}{X_{t}} \cdot \frac{X_{it}^{N}}{X_{it}}$$

- Rewrite (1) to obtain
- (2a)

$$\Delta\left(\frac{X_{it}^{N}}{X_{t}}\right) = \Delta\left(\frac{X_{it}}{X_{t}}\right)\left(\frac{X_{it}^{N}}{X_{it}}\right) + \Delta\left(\frac{X_{it}^{N}}{X_{it}}\right)\left(\frac{X_{it}}{X_{t}}\right)$$

- (2b)

$$\underbrace{\Delta\left(\frac{X_{it}^{N}}{X_{t}}\right)}_{\text{Change of New Products Export to Total Exports Share}} = \underbrace{\Delta\left(\frac{X_{it}}{X_{t}}\right)\frac{1}{2}\left(\frac{X_{it}^{N}}{X_{it}} + \frac{X_{it-1}^{N}}{X_{it-1}}\right)}_{\text{Scale Expansion Effect}} + \underbrace{\Delta\left(\frac{X_{it}^{N}}{X_{it}}\right)\frac{1}{2}\left(\frac{X_{it}}{X_{t}} + \frac{X_{it-1}}{X_{t-1}}\right)}_{\text{New Products Effect}}$$

Results of Equation (2b)

Table 3. Decomposition of New Products Export

Year	Changes of New Products Export to Total Exports Share	Scale Expansion Effect	New Products Effect
2002	0.4	0.7	-0.3
2003	-4.0	-0.1	-3.9
2004	3.5	0.8	2.8
2005	-1.4	0.1	-1.5
2006	0.2	0.3	-0.1
2007	1.4	0.3	1.1
2008	3.4	0.3	3.0

Note: Numbers are in percentage.

Source: Author's calculations based on data from *China Industry Economy Statistica Yearbook* and *Statistics on Science and Technology Activities of Industrial Enterprises*, various years.

Knowledge Production Functions

- We examine the relationship between R&D investment, technology transfer and new products export.
- Jefferson et al. (2006) developed a simple knowledge production function estimating the relationship between R&D inputs and R&D outputs (new products sales to total sales) for China's LMEs.
- Instead of new products sales to total sales, we use *New products export/Exports* and *Export/Total Export shares* as the output of a knowledge production function.
- We augment their empirical model to include technology transfer intensity.

Knowledge Production Functions (4a, 4b, 4c)

(X=export, N=new products, i=industry, t=year)

- (3)

$$\underbrace{\ln\frac{X_{it}^{N}}{X_{t}}}_{\text{New Products Export to Total Exports Share}} = \underbrace{\ln\frac{X_{it}}{X_{t}}}_{\text{Export Scale}} + \underbrace{\ln\frac{X_{it}^{N}}{X_{it}}}_{\text{New Products Export}}$$

- (4a)

$$\ln\frac{X_{it}^{N}}{X_{t}} = c_a + \beta_{a0}\ln R\&D_{it-1} + \beta_{a1}\ln FT_{it-1} + \beta_{a2}\ln DT_{it-1} + \beta_{a3}(\ln R\&D\times\ln FT)_{it-1} + \beta_{a4}(\ln R\&D\times\ln DT)_{it-1} + (\beta_{a5}\ln USimport_{it-1}) + \delta_a Z_i + \varepsilon_a$$

- (4b)

$$\ln\frac{X_{it}}{X_{t}} = c_b + \beta_{b0}\ln R\&D_{it-1} + \beta_{b1}\ln FT_{it-1} + \beta_{b2}\ln DT_{it-1} + \beta_{b3}(\ln R\&D\times\ln FT)_{it-1} + \beta_{b4}(\ln R\&D\times\ln DT)_{it-1} + (\beta_{b5}\ln USimport_{it-1}) + \delta_b Z_i + \varepsilon_b$$

- (4c)

$$\ln\frac{X_{it}^{N}}{X_{it}} = c_c + \beta_{c0}\ln R\&D_{it-1} + \beta_{c1}\ln FT_{it-1} + \beta_{c2}\ln DT_{it-1} + \beta_{c3}(\ln R\&D\times\ln FT)_{it-1} + \beta_{c4}(\ln R\&D\times\ln DT)_{it-1} + (\beta_{c5}\ln USimport_{it-1}) + \delta_c Z_i + \varepsilon_c$$

Explanatory Variables-1

- *R&D*: R&D intensity, R&D expenditure/sales
- *FT*: Foreign technology intensity, foreign technology purchase/sales
- *DT*: Domestic technology intensity, domestic technology purchase/sales

- *Interaction terms*:

  There is possible complementary effect - internal R&D is likely to enhance the "absorptive capability" of firms to advanced technology (Cohen and Levinthal, 1989).

  We follow Hu and Jefferson (2005) to include interaction terms.

Explanatory Variables-2

- As a proxy for the overseas demand of China's products, we use data for *United States' imports from the whole world*.
- The imports by the United States at HS four-digit level come from United Nations' Comtrade Database, downloaded from the World Integrated Trade Solution (WITS).
- Following Yu (2009), we aggregated them to import share (industry *i*'s import to total imports by the United States) at industry level in concordance with China's two-digit industrial classification.
- *Z*: vector of dummies, including year dummy and foreign capital-intensive industry dummy.

Table 4. Estimation Results of Equation (4a), (4b), and (4c)

Dependent Variables	New Products Export to Total Exports Share		Export Scale		New Products Export	
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
R&D Intensity (t-1)	6.058	3.942	4.343	1.676	1.715	2.266
	[1.707]***	[1.355]***	[1.351]***	[0.923]*	[0.773]**	[0.635]***
Foreign Tech (t-1)	3.432	2.300	2.748	1.321	0.684	0.979
	[1.172]***	[1.070]**	[1.011]**	[0.860]	[0.532]	[0.425]**
Domestic Tech (t-1)	0.592	0.337	0.290	-0.032	0.302	0.369
	[1.142]	[0.966]	[0.992]	[0.788]	[0.330]	[0.358]
R&D Intensity*Foreign Tech (t-1)	0.580	0.373	0.476	0.214	0.104	0.158
	[0.207]***	[0.185]*	[0.175]**	[0.143]	[0.096]	[0.074]**
R&D Intensity*Domestic Tech (t-1)	0.121	0.054	0.081	-0.003	0.040	0.058
	[0.210]	[0.176]	[0.181]	[0.142]	[0.061]	[0.066]
U.S. Import (t-1)		0.402		0.507		-0.105
		[0.178]**		[0.131]***		[0.069]
Foreign Capital-intensity Quantile 2	0.268	0.275	0.111	0.120	0.157	0.155
	[0.421]	[0.439]	[0.391]	[0.330]	[0.212]	[0.179]
Foreign Capital-intensity Quantile 3	0.172	0.249	0.232	0.329	-0.060	-0.080
	[0.542]	[0.544]	[0.499]	[0.455]	[0.187]	[0.156]
Foreign Capital-intensity Quantile 4	0.925	0.984	0.902	0.977	0.023	0.008
	[0.516]*	[0.577]*	[0.410]**	[0.389]**	[0.283]	[0.241]
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	25.996	17.117	18.322	7.127	7.674	9.989
	[8.917]***	[7.644]**	[6.797]**	[5.170]	[4.154]*	[3.514]***
Number of Observations	201	201	201	201	201	201
Number of Clusters	29	29	29	29	29	29
R-squared	0.507	0.566	0.332	0.508	0.630	0.645

Notes: All variables are in logarithm except foreign capital intensity quantiles and year dummies. Coefficients are estimated by OLS. Robust standard errors are in brackets.
*** Significant at 1%, ** significant at 5%, * significant at 10%.

Robustness Check

- We make robustness check by other two variables, *skill intensity* and *capital intensity*.

- These two variables are strongly correlated with R&D intensity and they may have similar effects on new products production and export.

Table 5. Results of Robustness Check

Dependent Variables	New Products Export to Total Exports Share				Export Scale				New Products Export			
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
R&D Intensity (t-1)	1.552			1.542	0.690			0.501	0.862			1.041
	[0.316]***			[0.308]***	[0.295]**			[0.323]	[0.133]***			[0.137]**
Skill Intensity (t-1)		1.258		0.478		0.566		1.220		0.692		-0.742
		[0.812]		[0.739]		[0.650]		[0.666]*		[0.257]**		[0.362]**
Capital Intensity (t-1)			-0.420	-1.129			-0.519	-1.354			0.099	0.225
			[0.805]	[0.661]*			[0.613]	[0.573]**			[0.322]	[0.276]
Foreign Capital-intensity Quantile 2	0.128	0.916	0.370	-0.142	0.112	0.464	0.095	0.034	0.016	0.452	0.275	-0.176
	[0.485]	[0.854]	[0.756]	[0.484]	[0.460]	[0.574]	[0.500]	[0.398]	[0.202]	[0.421]	[0.400]	[0.164]
Foreign Capital-intensity Quantile 3	-0.027	0.703	-0.115	-0.377	0.191	0.518	-0.019	0.094	-0.218	0.184	-0.096	-0.471
	[0.603]	[1.031]	[0.866]	[0.625]	[0.565]	[0.756]	[0.622]	[0.563]	[0.186]	[0.407]	[0.378]	[0.150]**
Foreign Capital-intensity Quantile 4	0.910	1.713	0.371	0.380	1.116	1.479	0.609	0.974	-0.207	0.234	-0.238	-0.594
	[0.618]	[1.244]	[1.208]	[0.915]	[0.565]*	[0.957]	[0.920]	[0.820]	[0.223]	[0.413]	[0.405]	[0.201]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.923	-4.633	-6.041	5.062	-0.948	-3.404	-3.197	3.945	1.872	-1.229	-2.844	1.117
	[1.629]	[1.808]**	[1.873]**	[2.623]*	[1.418]	[1.342]**	[1.449]**	[2.253]*	[0.633]***	[0.793]	[0.679]***	[1.023]
Number of Observations	201	201	201	201	201	201	201	201	201	201	201	201
Number of Clusters	29	29	29	29	29	29	29	29	29	29	29	29
R-squared	0.439	0.097	0.046	0.489	0.247	0.120	0.129	0.339	0.596	0.173	0.102	0.625

Notes: All variables are in logarithm except foreign capital intensity quantiles and year dummies.
Coefficients are estimated by OLS. Robust standard errors are in brackets. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Concluding Remarks-1

- Main finding:

  Both R&D investments and technology transfers from abroad contribute significantly to the rising sophistication of China's exports.

- Policy Implication:

  Chinese government should direct more tax incentives and subsidies to those industries that zealously engage in both in-house R&D and market-mediated foreign technology transfers.

Concluding Remarks-2

- Cautions:

  1. We do not deny that processing trade accounts for an important part of rising export sophistication argued in recent literature.

  2. We are not able to distinguish ownerships in our samples.

- Future research:

  1. Investigate this theme by firm ownership or by region.

  2. Using firm-level data and Customs Statistics will help us examine this theme more comprehensively and more precisely.

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ご清聴、ありがとうございました。