Tickets to the Global Market: First U.S. Patents and Chinese Firm Exports

Robin Kaiji Gong[1], Yao Amber Li[2], Kalina Manova[3], Stephen Teng Sun[4]

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[1]The Hong Kong University of Science and Technology. Email: rkgong@ust.hk.
[2]The Hong Kong University of Science and Technology. Email: yaoli@ust.hk.
[3]University College London. Email: k.manova@ucl.ac.uk.
[4]City University of Hong Kong. Email: tengsun@cityu.edu.hk.

Patent Globalization

- Global patent activity has increased steadily in recent decades
  - Remarkable rise in patents taken out by foreign firms in a select few patent jurisdictions, especially from emerging economies
  - Ex: share of foreign applicants to United States Patent and Trademark Office (USPTO) up from 44% in 2000 to 51% in 2015
- First-order questions:
  - Why do firms patent their innovations abroad?
  - Can established patent authorities in developed countries act as global hubs for alleviating challenges faced by firms from emerging economies when they participate in the global marketplace?

U.S. Patents and Worldwide Exports across Countries

Note: The figures shows the correlation between country-level U.S. patent growth and growth of export to the US/ROW from 2000 to 2010. U.S. patent data is obtained from the United States Patent and Trademark Office (USPTO). Export data is obtained from the World Integrated Trade Solution (WITS) database.

- U.S.'s reputation for strict patent and IPR standards may confer advantages to USPTO patent holders that extent beyond market protection in the U.S.

This Paper: U.S. Patents and Chinese Exports

- How does U.S. patent approval affect the export performance of Chinese firms?
  - Match rich data on USPTO patent applications, Chinese customs transactions, and Chinese accounting statements
  - Compare successful to unsuccessful first-time applicants
  - Instrument patent approval with leniency of randomly assigned USPTO examiner (Sampat and Williams, 2019; Farre-Mensa et al., 2020)
  - Identify causal effect of U.S. patent and explore possible mechanisms
- Ideal institutional context
  - Top-3 trading economies, advanced with strong institutions vs. emerging with rapid structural transformation
  - Stigma about quality of Chinese products and Chinese patent system
  - U.S. both important market and top patent office for Chinese firms

Results

1. Successful first USPTO application improves Chinese firms' export growth
   - **17.6%** higher annualized export growth for successful than that unsuccessful applicants
   - Driven by survival and expansion in incumbent destination-product markets (88%)
   - Battery of specification checks: balance tests, event study, placebo, robustness
2. Mechanism I: monopoly power in the U.S.
   - Effect on exports of patent-related products to U.S., but even larger effect on unrelated products to ROW
3. Mechanism II: signaling under information frictions
   - Product quality: bigger effect on exports of differentiated products to high-income countries
   - Firm credibility: bigger effect on exports of contract intensive industries to high rule-of-law countries
4. No Mechanisms III: financial constraints, follow-on innovation

Contribution

- **Effects of patenting on firm operations**: we study how cross-border patent activity is related to firms' export performance
  - Williams (2013, 2017); Galasso and Schankerman (2015); Cockburn et al. (2016); Palangkaraya et al. (2017); Galasso and Schankerman (2018); Kline et al. (2019); Sampat and Williams (2019); Farre-Mensa et al. (2020); Rassenfosse et al. (2022)
- **Firm productivity, innovation, and trade**: we identify the causal effect of patenting conditional on firms' innovation prowess
  - Lileeva and Trefler (2010); Aw et al. (2011); Bustos (2011); Bøler et al. (2015); Aghion et al. (2018); Liu and Ma (2020); Maican et al. (2020); Coelli et al. (2022)
- **Information asymmetry in international trade**: we provide novel evidence that obtaining patent recognition from a global patent hub can signal quality capacity and contractual credibility for firms in developing countries
  - Rauch (1999, 2001); Banerjee and Duflo (2000); Casella and Rauch (2002); Rauch and Trindade (2003); Feenstra and Hanson (2004); Ahn et al. (2011); Chaney (2014); Macchiavello and Morjaria (2015); Monarch and Schmidt-Eisenlohr (2017); Steinwender (2018); Akerman et al. (2022); Rauch and Trindade (2022)

Data

Data Sources

- USPTO Patent Examination Research Dataset (PatEx, 2001-2016)
  - Rich information about universe of patent applications
    - basic information about patent applicants
    - identity of patent examiners
    - outcome at each examination step
- Chinese Customs Trade Statistics (CCTS, 2000-2016)
  - universe of export and import transactions
  - transaction-level product code, country, value, quantity etc
- Chinese Annual Survey of Industrial Enterprises (ASIE, 1998-2013)
  - operational and financial information of above-scale industrial firms.

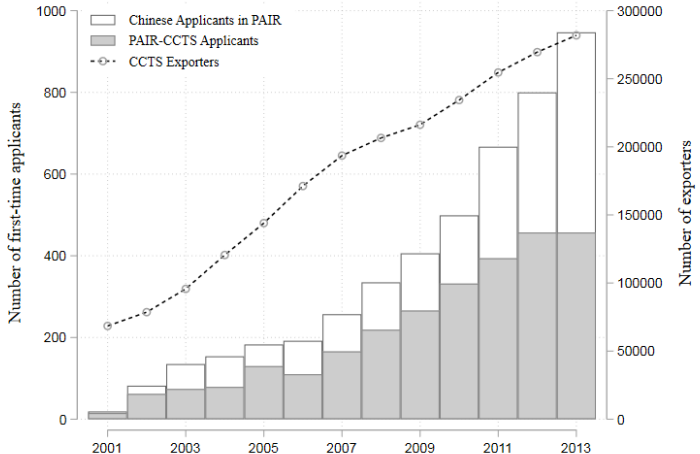
First-time Chinese Applicants in the USPTO

1. We identify Chinese applicants in PatEx based on their location information.
   - Applicant sample starts in 2001 (only approved applicants before 2001)
   - Restrict sample to incorporated applicants
   - Drop applicants from Hong Kong and Macau
   - Standardize applicants' English names

2. We manually match Chinese PatEx patent applicants to CCTS exporters based on name and location (from English to Chinese)
   - Cross-checks based on patent and business registration records
   - Secondary match from CCTS to ASIE standard in the literature

⏩ Illustrative Example

Number of First-time U.S. Patent Applicants from China

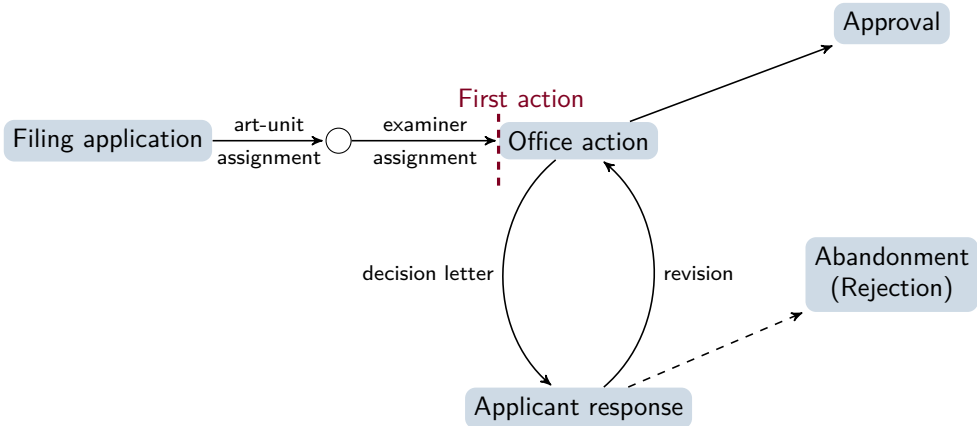


Note: The figure shows the number of first-time U.S. patent applicants from China by first action year. The white bars display the total number of USPTO applicants located in China. The shadowed bars display the total number of CCTS-PAIR matched exporters. The dashed line displays the total number of exporters in CCTS data.

Technology Classes Comparison of U.S. Patent Applicants and Other Exporters

Empirical Strategy

The Patent Examination Process



Illustrative Example

Empirical Setup

We adopt the following generalized specification to estimate the effect of a successful first U.S. patent application on Chinese firms' export growth:

$$\begin{aligned}\Delta_k Export_{it+k} &\equiv \frac{Export_{it+k} - Export_{it}}{0.5(Export_{it+k} + Export_{it})} \\ &= \beta \cdot \mathbb{1}(\text{Success First App} = 1)_{iajt} + \Gamma Z_{it} + \lambda_{s\tau} + \epsilon_{it+k}\end{aligned}$$

- i = exporter, a = art unit, j = examiner, t = first-action year, $k \equiv 3$ in baseline
- X_{it} controls: log initial exports, export tenure
- $\lambda_{s\tau}$: HS2 sector by application year pair fixed effects
- Coefficient of interest: β
  - OVB: patent application outcome might be correlated with unobserved firm characteristics such as inherent innovation capacity or realized innovation quality

⏭ Export Growth since First Application

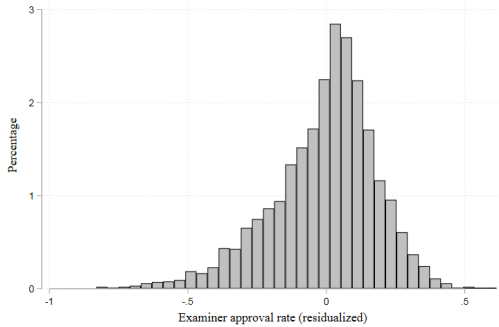
IV Strategy

Identification exploits USPTO idiosyncrasy

- Patent examiners assigned quasi-randomly within technology-determined art units
- Examiners differ in their ex-ante approval propensity

$$Approval\ Rate_{iajt} = \frac{\#Granted_{iajt}}{\#Examined_{iajt}}$$

- $\#Granted_{iajt}$ ($\#Examined_{iajt}$) = patents that examiner j has granted (examined) in art unit a prior to her decision on i's application at time t
- We residualize approval rates within at to guard against (unlikely) strategic application timing



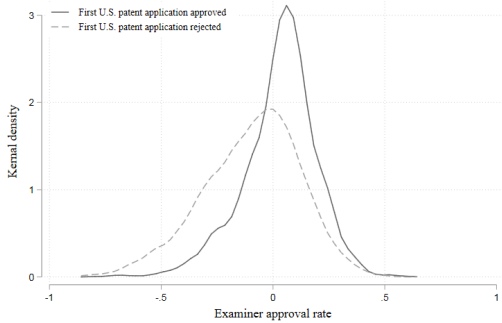
Note: The figure shows the sample distribution of approval rates of patent examiners assigned to CCTS applicants from China, estimated within each art-unit by first-action year group.

First-Stage IV Validity

We instrument $\mathbb{1}(\text{Success First App} = 1)_{iajt}$ by the residualized $\textit{Approval Rate}_{iajt}$.

Dependent variable	*Successful first application*			
	(1)	(2)	(3)	(4)
Examiner approval rate	0.971***	0.969***	0.954***	0.959***
	(0.0693)	(0.0696)	(0.0778)	(0.0781)
Log export		0.00209		0.0151**
		(0.00567)		(0.00752)
Export tenure		-0.00789*		-0.00204
		(0.00437)		(0.00509)
Log employment				-0.0108
				(0.0107)
HS2-year fixed effects	Yes	Yes		
Industry-year fixed effects			Yes	Yes
Ownership-year fixed effects			Yes	Yes
Sample	CCTS		CCTS-ASIE	
F-test: IV = 0	196.51***	193.92***	150.44***	150.97***
Observations	1156	1156	941	941

Note: The table reports first-stage regression results. We predict whether an exporter's first USPTO patent application is approved by the assigned examiner's *ex-ante* residualized approval rate. The sample of Column 1 and 2 covers all CCTS-PAIR matched exporters, and the sample of Column 3 and 4 covers those CCTS-ASIE-PAIR matched exporters. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.



Note: The figure shows the kernel density of examiner approval rates by whether the exporter's first patent application is successful or not. The sample covers all CCTS-PAIR matched exporters. Examiner approval rates are estimated within each art-unit by first-action year group.

Balance Test Testing for Examiner Specialization

Effect of First U.S. Patent on Chinese Firm Exports

First US Patent Promotes Chinese Export Growth

Dependent variable	*Annualized 3-year export growth*					
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.0667***	0.174***	0.178***	0.0601**	0.218***	0.204***
	(0.0214)	(0.0568)	(0.0525)	(0.0253)	(0.0692)	(0.0623)
Log export			-0.0367***			-0.0460***
			(0.00492)			(0.00596)
Export tenure			-0.00297			-0.0139***
			(0.00366)			(0.00372)
Log employment						0.0294***
						(0.00858)
HS2-year fixed effects	Yes	Yes	Yes			
Industry-by-year fixed effects				Yes	Yes	Yes
Ownership-by-year fixed effects				Yes	Yes	Yes
Models	OLS	2SLS	2SLS	OLS	2SLS	2SLS
Sample		CCTS			CCTS-ASIE	
K-P rk Wald F-stats		196.51	193.92		150.44	150.97
Observations	1156	1156	1156	941	941	941

Note: The table reports the estimated effect of successful first U.S. patent application on export growth of Chinese applicants. The dependent variable is annualized 3-year growth rate of export value. Columns 1, 2, and 3 include all CCTS-PAIR matched exporters, and columns 4, 5, and 6 include CCTS-ASIE-PAIR matched exporters, and control for 2-digit industry-year fixed effects and ownership-year fixed effects. Columns 1 and 4 are estimated with OLS, and the rest are estimated with 2SLS, using the residualized examiner approval rates as instruments. Column 3 includes log initial export value and export tenure as controls; column 4 includes log employment as additional controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Event Study · Placebo Test · The Effect of Second Application · Alternative Specifications · Other Export Outcomes

Decomposition of Patent-Induced Export Growth

Main driver (88%): survival and expansion in incumbent destination-product markets

Dependent variables	*Components of annualized 3-year export growth*					
	All	All	Existing	Existing	New	New
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.174***	0.178***	0.156***	0.156***	0.0182	0.0216
	(0.0568)	(0.0525)	(0.0488)	(0.0489)	(0.0311)	(0.0262)
Log export		-0.0367***		-0.00563		-0.0311***
		(0.00492)		(0.00407)		(0.00232)
Export tenure		-0.00297		-0.0000639		-0.00290*
		(0.00366)		(0.00314)		(0.00149)
K-P rk Wald F-stats	196.51	193.92	196.51	193.92	196.51	193.92
Observations	1156	1156	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column controls for HS2 by application year fixed effects. Column 2, 4, and 6 include log initial export value and export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The Decomposition Method · Three-part Decomposition · ASIE Decomposition

Firm-product-destination Level Outcomes

Why Does First U.S. Patent Boost Chinese Firm Exports?

Mechanism I: Monopoly Power

Hypothesis 1: U.S. patent rights strengthen exporters' monopoly power and sales of protected products in the U.S. market, but not of other products or markets

To test Hypothesis 1, we examine:

- whether the baseline patent effect on exports is driven by the technologically related products sold in the U.S.
- whether the values and prices of those export flows are improved

We use USCPC-HS6 crosswalk to identify technologically related products (ALP weights $> 5\%$) potentially protected by a patent (Goldschlag, et al. (2020))

◂ The weighting algorithm

Weak Evidence for Monopoly Power Mechanism

Evidence 1a: Export growth decomposition

- Patent effect is mainly driven by rising exports of technologically unrelated products to ROW, and only in small part by exports of related products to the U.S

Panel A. Decomposition by destination/product types

	By destinations		By Products	
	U.S.	ROW	Related	Unrelated
Successful First Application	0.0219	0.156***	0.0408	0.137***
	(0.0249)	(0.0428)	(0.0276)	(0.0488)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types

	U.S. + Related	U.S. + Unrelated	ROW + Related	ROW + Unrelated
Successful First Application	0.0259*	-0.00406	0.0149	0.141***
	(0.0136)	(0.0214)	(0.0225)	(0.0403)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

◂ Growth rate by types ◂ Decomposition with alternative definition of technology relevance

Weak Evidence for Monopoly Power Mechanism

Evidence 1b: Within-firm analysis at firm-product-destination level

- Firms do not increase sales and prices differentially for technologically related products exported to the U.S.

Product-destination level analysis: the monopoly power channel

	Value growth			Price growth		
Technology relatedness	All	Yes	No	All	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × U.S.	0.114	-0.131	0.140	0.0489	0.0426	0.0157
	(0.116)	(0.246)	(0.122)	(0.0651)	(0.166)	(0.0745)
Controls	Product-destination level log export and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
K-P rk Wald F-stats	6.89	7.66	5.85	6.29	8.85	5.15
Observations	38822	7775	30409	31222	6635	24059

Note: The table reports the heterogeneous effect of successful first U.S. patent application on the value and price growth of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 contain all continuing product-destination pairs of CCTS-PAIR matched exporters, columns 2 and 5 contain continuing pairs of products technologically related to the U.S. patent, and columns 3 and 6 contain continuing pairs of unrelated products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

◂ Specification ◂ Analysis with alternative definition of technology relatedness

Mechanism II: Asymmetric Information

Hypothesis 2: U.S. patent grant constitutes a signal that can alleviate information frictions in international trade

- Product quality signal: firms' quality capacity under quality differentiation
- Contractual credibility signal: firms' trustworthiness under contractual frictions

To test Hypothesis 2, we examine:

- (*quality*) whether U.S. patents increase firm exports disproportionately more for more differentiated products (Rauch, 1999) and richer destinations
- (*credibility*) whether U.S. patents increase firm exports disproportionately more for more contract-intensive products (Nunn, 2007) and destinations with stronger rule of law (Kaufmann et al., 2003).

Strong Evidence for Product Quality Signal

Evidence 2a: Export growth decomposition

- Patent effect is mainly driven by goods with greater scope for quality differentiation and high-income countries wiht greater willingness to pay for quality

Panel A. Decomposition by destination/product types

	By destinations		By Products	
	High income	Low income	Differentiated	Non-differentiated
Successful First Application	0.129***	0.0485**	0.164***	0.0170
	(0.0458)	(0.0243)	(0.0456)	(0.0231)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types

	HI+Diff.	HI+Non-diff.	LI+Diff.	LI+Non-diff.
Successful First Application	0.129***	0.0132	0.0347**	0.00399
	(0.0376)	(0.0220)	(0.0175)	(0.00574)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Strong Evidence of Product Quality Signal

Evidence 2b: Within-firm analysis at firm-product-destination level

- Higher export survival in richer countries, driven by differentiated goods

Product-destination level analysis: the quality signal channel

	Survival Indicator			Value growth		
Product Differentiation	All	Yes	No	All	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × ln(GDP per capita)	0.0206*	0.0302**	0.00196	0.00304	-0.00384	0.0327
	(0.0120)	(0.0131)	(0.0247)	(0.0195)	(0.0221)	(0.0405)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats	32.30	26.52	50.70	20.85	18.11	17.26
Observations	85955	70123	10555	38665	32251	4112

Note: The table reports the heterogeneous effect of successful first U.S. patent application on the survival rates (value growth) of incumbent (continuing) product-destination pairs. The analysis is conducted at firm-product-destination level. Column 1 (4) contain all incumbent (continuing) product-destination pairs of CCTS-PAIR matched exporters, column 2 (5) contain incumbent (continuing) pairs of differentiated products, and column 3 (6) contain incumbent (continuing) pairs of other products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

◂ Analysis based on Price CV

Strong Evidence of Contractual Credibility Signal

Evidence 3a: Export growth decomposition

- Patent effect is mainly driven by contract-intensive sectors with high relationship-specific investments and countries with better contract enforcement

Panel A. Decomposition by destination/product types

	By destinations		By Products	
	High RLI	Low RLI	High Contract Int.	Low Contract Int.
Successful First Application	0.151***	0.0277	0.132***	0.0500**
	(0.0463)	(0.0232)	(0.0460)	(0.0221)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types

	HRLI+High CI	HRLI+Low CI	LRLI+High CI	LRLI+Low CI
Successful First Application	0.118***	0.0374**	0.0149	0.0127
	(0.0422)	(0.0186)	(0.0176)	(0.00984)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

◂ Growth rate by types

String Evidence of Contractual Credibility Signal

Evidence 3b: Within-firm analysis at firm-product-destination level

- Higher export survival in higher rule-of-law countries, driven by contract intensive goods

Product-destination level analysis: the reliability signal channel

	Survival Indicator			Value growth		
Contract Intensity	All	High	Low	All	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × Rule-of-law Index	0.0307**	0.0360**	0.0245	0.00529	0.00340	0.0261
	(0.0150)	(0.0147)	(0.0304)	(0.0244)	(0.0235)	(0.0533)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats	25.73	23.60	21.71	17.23	14.05	13.50
Observations	86319	56481	29237	38752	26283	12009

Note: The table reports the heterogeneous effect of successful first U.S. patent application on the survival rates (value growth) of incumbent (continuing) product-destination pairs. The analysis is conducted at firm-product-destination level. Column 1 (4) contain all incumbent (continuing) product-destination pairs of CCTS-PAIR matched exporters, column 2 (5) contain incumbent (continuing) pairs of contract intensive products, and column 3 (6) contain incumbent (continuing) pairs of other products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

◂ Analysis based on Upstreamness

Ruling Out Other Mechanisms

- Financial frictions
  - U.S. patents may signal higher expected future profits and thereby attract external investors and ease financial frictions faced by exporters
  - However, effect of U.S. patent on exports is not systematically higher for exporters more active in financially vulnerable sectors ◂ Testing the financial constraint mechanism
- Follow-on innovation and patenting
  - First U.S. patent may improve exporters' expectations about their future innovation or patenting success, and hence induce them to conduct more R&D, upgrade product quality, and climb up the value chain.
  - However, we find little evidence that the first U.S. patent stimulates patenting in China. ◂ Patent filing in China

Conclusions

Conclusions

- We identify a large causal effect of a successful first U.S. patent application on a Chinese firm's subsequent export growth
- Unpacking potential mechanisms, we find evidence consistent with U.S. patents signaling product quality and contractual credibility under asymmetric information
  - Limited evidence for monopoly power mechanism
  - No evidence for financial frictions and follow-on innovation mechanisms
- Open questions
  - Global patent policy
  - Welfare effects of patent hubs
  - Trade and patents with GVCs and MNCs

Thanks!

Appendix

An Illustrative Example of the Matching Procedures

Take **Shanghai Microelectronics Equipment Co.** as an example.

1. The company filed its first U.S. patent application on Aug. 19, 2005.
   - It was about an electronic component.
   - The patent was granted on Mar. 4, 2008 (it normally takes 2.5-3 years).
2. We search the keywords "Microelectronics Equipment" and "Shanghai" in search engines.
   - The company's registered Chinese name is: 上海微电子装备有限公司
   - We cross-check the names with a database of company registrations (*Tianyancha*).

(12) **United States Patent**
Wang et al.

(10) **Patent No.: US 7,339,289 B2**
(45) **Date of Patent: Mar. 4, 2008**

(54) **SYNCHRONOUS PERMANENT MAGNET PLANAR MOTOR**

(75) Inventors: **Jinsong Wang**, Beijing (CN); **Yu Zhu**, Beijing (CN); **Jiayong Cao**, Beijing (CN); **Wensheng Yin**, Beijing (CN); **Guanghong Duan**, Beijing (CN)

(73) Assignees: **Tsinghua University**, Beijing (HK); **Shanghai MicroElectronics Equipment Co., Ltd.**, Shanghai (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/207,425**

(22) Filed: **Aug. 19, 2005**

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(30) **Foreign Application Priority Data**

Aug. 20, 2004 (CN) 2004 1 0069472

(51) **Int. Cl.**
H20K 41/00 (2006.01)

(52) **U.S. Cl.** **310/12**; 310/13; 310/15

(58) **Field of Classification Search** 310/12, 310/13, 15
See application file for complete search history.

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Primary Examiner—Darren Schuberg
Assistant Examiner—Iraj A. Mohandesi
(74) *Attorney, Agent, or Firm*—Michael Best & Friedrich LLP

(57) **ABSTRACT**

According to the invention, configurations of X-windings and Y-windings in a synchronous permanent planar motor are improved, X-windings and Y-windings overlap in the direction normal to the planar magnet array and distribute on the entire surface of the thrust core, such that effective wires in the X-windings and Y-windings are lengthened and increased in number, therefore the electromagnetic force generated by the SPMPM of this invention is increased correspondingly; X-windings and Y-windings are mounted on a thrust core made of iron material, thus the electromagnetic force is further increased; in addition, two separated anti-yawing member are provided on the mover for counteracting yawing of the mover, accordingly interference between anti-yawing torque and the electromagnetic force for propelling is eliminated.

8 Claims, 6 Drawing Sheets

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Technology Classes of First Patent Applications

Sample: all first-time U.S. patent applicants from China

Rank	USPC class	USPC title	Number	Percentage (%)
1	514	Drug, bio-affecting and body treating compositions	266	5.55
2	424	Drug, bio-affecting and body treating compositions	196	4.09
3	435	Chemistry: molecular biology and microbiology	144	3.01
4	362	Illumination	112	2.34
5	439	Electrical connectors	84	1.75
6	257	Active solid-state devices	77	1.61
7	455	Telecommunications	71	1.48
8	361	Electricity: electrical systems and devices	69	1.44
9	428	Stock material or miscellaneous articles	68	1.42
10	345	Computer graphics processing and selective visual display systems	67	1.40
		Other	3637	75.91

Sample: first-time U.S. patent applicants matched to CCTS

Rank	USPC class	USPC title	Number	Percentage (%)
1	424	Drug, bio-affecting and body treating compositions	117	4.13
2	514	Drug, bio-affecting and body treating compositions	96	3.39
3	362	Illumination	86	3.04
4	435	Chemistry: molecular biology and microbiology	80	2.83
5	439	Electrical connectors	66	2.33
6	428	Stock material or miscellaneous articles	50	1.77
7	257	Active solid-state devices	45	1.59
8	345	Computer graphics processing and selective visual display systems	41	1.45
9	361	Electricity: electrical systems and devices	40	1.41
10	536	Organic compounds	34	1.20
		Other	2116	76.86

Note: The table shows the top technology classes of the first patent applications filed by Chinese applicants. The top panel displays the top 10 technology classes filed by all first-time U.S. patent applicants from China; the bottom panel displays the top 10 technology classes filed by CCTS-PAIR matched first-time U.S. patent applicants.

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Comparison of U.S. Patent Applicants and Other Exporters

	Matched patent applicants		*Other exporters*		*Differences*	
	Mean	sd	Mean	sd	Mean	sd
Log value of export	15.28	2.71	13.16	2.34	2.12***	0.021
Log value of export to the U.S.	10.01	6.61	5.00	6.14	5.01***	0.054
Log value of export to OECD	13.14	5.11	9.94	5.65	3.21***	0.050
Share of export to U.S.	0.22	0.30	0.14	0.28	0.090***	0.0025
Share of export to OECD	0.54	0.36	0.52	0.41	0.024***	0.0037
Number of products	16.18	40.87	14.58	48.41	1.59***	0.43
Number of destinations	19.68	21.14	8.39	12.76	11.29***	0.11
Average value per prod.-dest. pair (1,000 RMB)	1423.76	8081.73	405.49	5826.35	1018.28***	51.67
Number of observations	12,850		2,318,957			

Note: The table displays the comparison of CCTS-PAIR matched exporters and other exporters in CCTS. Column 1 and 2 show the mean and standard deviations of key export statistics of the CCTS-PAIR matched Chinese patent applicants across all years; Column 3 and 4 show the mean and standard deviations of key export statistics of the other exporters across all years. Column 5 and 6 show the mean and standard deviation of the differences in export statistics between the two groups. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Comparison of U.S. Patent Applicants and Other Exporters

	Matched patent applicants		*Other exporters*		*Differences*	
	Mean	sd	Mean	sd	Mean	sd
Log value of processing export	9.04	7.63	4.86	6.37	4.18***	0.056
Log value of export of heterogeneous products	13.41	5.19	11.25	4.87	2.15***	0.043
Log value of export to high-RLI countries	14.45	4.08	11.80	4.34	2.65***	0.038
Log value of export to high-IPR countries	15.00	3.13	12.44	3.55	2.57***	0.031
Share of processing export	0.34	0.41	0.20	0.35	0.14***	0.0031
Share of heterogeneous products	0.75	0.39	0.76	0.39	-0.0070**	0.0034
Share of export to high-RLI countries	0.81	0.27	0.76	0.34	0.043***	0.0030
Share of export to high-PRI countries	0.90	0.20	0.85	0.28	0.051***	0.0025
Number of observations	12,850		2,318,957			

Note: This table displays the additional comparison of CCTS-PAIR matched exporters and other exporters in CCTS. Column 1 and 2 show the mean and standard deviations of key export statistics of the CCTS-PAIR matched Chinese patent applicants across all years; Column 3 and 4 show the mean and standard deviations of key export statistics of the other exporters. Column 5 and 6 show the mean and standard deviation of the differences in export statistics between the two groups. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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An Illustrative Example of the Patent Examination Process

Still take **Shanghai Microelectronics Equipment Co.** as an example.

1. The company filed its first patent application (US7339289B2) on Aug. 19, 2005.
2. The case was first assigned to the art unit 2834, and then assigned to an examiner, Iraj Mohandesi, on Jul. 10, 2006.
   - Mr. Mohandesi examined 419 patent applications, of which 365 were finally approved.
3. The first action (a non-final rejection) was issued on **Aug. 10, 2006**.
   - The first action decision normally takes place about 1.5-2 years after the initial filing (Dyer et al., 2020).
   - We define the first *Notice of Allowance* or *Non-final Rejection*, whichever comes first, as the first action by USPTO.
   - The first action (initial decision) date is used as the starting point of the effect (Kline et al., 2019; Farre-Mensa, Hegde, and Ljungqvist, 2020).
     - Much of the uncertainty is resolved by the first action.
   - The application underwent another round of non-final rejection before obtaining a notice of allowance.
4. The patent was granted on Mar. 4, 2008.

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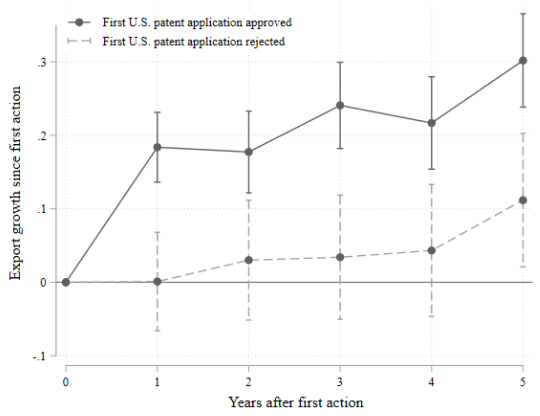
Export Growth since First Application



Note: The figure shows the average export growth of successful first-time patent applicants and unsuccessful first-time patent applicants, since the first action years of applications. Export growth is measured as $g_{ik} = (exp_{it+k} - exp_{it})/0.5(exp_{it+k} + exp_{it})$, where exp_{it} is the export value of firm i in t, the first action year of its first patent application. exp_{it+k} is the export value of firm i k years after t. 95% confidence intervals are represented by the capped spikes.

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Balance Tests

Sample	*Characteristics*	*Successful first application*	*Examiner approval rate*
CCTS (Sample size = 1156)	Log export (Custom)	-0.0209	0.123
		(0.162)	(0.465)
	Log # products	-0.143*	-0.0787
		(0.0758)	(0.227)
	Log # destinations	-0.0266	0.156
		(0.0745)	(0.198)
	Log average export (prod.-dest. pair)	0.0875	0.0255
		(0.125)	(0.376)
	Log sales	0.0456	-0.337
		(0.142)	(0.342)
	Log employment	-0.00509	0.0276
		(0.0986)	(0.245)
CCTS-ASIE (Sample size = 941)	Log export (ASIE)	0.258	-0.294
		(0.191)	(0.536)
	Operating profit	0.0100	-0.0320
		(0.00931)	(0.0225)

Note: The table reports results of regressing CCTS or CCTS-ASIE matched exporters' *ex-ante* characteristics on first application successes and examiners' approval rates. The CCTS sample covers all continuing exporters matched to USPTO patent applicants. The ASIE sample covers the continuing exporters also matched with ASIE. Regressions on the CCTS sample control for HS2 by application year fixed effects. Regressions on the CCTS-ASIE sample control for CIC2 by application year fixed effects and ownership type by year fixed effects. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Balance Tests

Sample	*Characteristics*	*Successful first application*	*Examiner approval rate*
CCTS (Sample size = 1156)	Share of Heterogeneous Exports	-0.0376*	0.0393
		(0.0201)	(0.0609)
	Share of Tech. Related Exports	0.0219	0.144**
		(0.0286)	(0.0668)
	Share of Processing Export	-0.0321	-0.0159
		(0.0254)	(0.0658)
	Share of Exports to the U.S.	-0.0405*	0.0134
		(0.0220)	(0.0468)
	Share of Exports to OECD Countries	-0.0474**	-0.0357
		(0.0212)	(0.0497)
	Share of Exports to High-RLI Countries	-0.0329**	-0.0610
		(0.0146)	(0.0389)
	Share of Exports to High-PR Countries	-0.0244*	-0.00636
		(0.0129)	(0.0356)

Note: The table reports results of regressing CCTS matched exporters' additional *ex-ante* characteristics on first application successes and examiners' approval rates. The CCTS sample covers all continuing exporters matched to USPTO patent applicants. All columns control for HS2 by application year fixed effects. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Testing for Examiner Specialization

Righi and Simcoe (2019) point out that examiners may specialize in certain patents.

- Validation test: "[U]nder random assignment, the inclusion of control variables should not affect the magnitude of the estimated coefficients."
  - We use an alternative instrument that also excludes technology class by application year fixed effects.
  - We include examiner characteristics as controls (examiner's experience and number of foreign/Chinese patents examined).
- The point estimates fluctuate between 80% to 100%.

Dependent variable	*Successful first application*			
	(1)	(2)	(3)	(4)
Examiner approval rate (residual 1)	0.969***	0.869***		
	(0.0698)	(0.0898)		
Examiner approval rate (residual 2)		0.00150	0.994***	0.871***
		(0.00572)	(0.0681)	(0.0886)
Log export	0.00254	-0.00765*	0.00305	0.00217
	(0.00568)	(0.00435)	(0.00579)	(0.00584)
Export tenure	-0.00801*	-0.00791*	-0.00769*	-0.00741*
	(0.00437)	(0.00437)	(0.00453)	(0.00448)
Log examined Chinese patents		-0.0137		-0.0167
		(0.0231)		(0.0236)
Log examined foreign patents		0.0606**		0.0764***
		(0.0267)		(0.0270)
Log examiner experience		-0.0479		-0.0592
		(0.0425)		(0.0428)
HS2-year fixed effects	Yes	Yes	Yes	Yes
F-test: IV = 0	193.92***	93.73***	213.10***	96.55***
Observations	1156	1156	1156	1156

Note: The table reports validation test results as suggested in Righi and Simcoe (2019). The sample covers all CCTS-PAIR matched exporters. Examiner approval rate (residual 1) is examiner's residualized approval rate after excluding art unit by application year fixed effects. Examiner approval rate (residual 2) is examiner's residualized approval rate after excluding both art unit by application year fixed effects and USPC technology class by application year fixed effects. HS2 by application year fixed effects are controlled in all columns. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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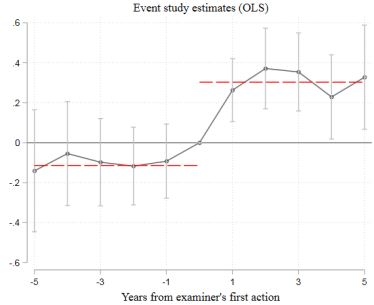
Event Study



Note: The figure shows the event study plot of the OLS estimates of the effect of successful first U.S. patent application on export. The sample covers all CCTS-PAIR matched exporters. The dependent variable is log export value, and the regressors include the indicator of first patent application outcome interacted with time dummies. Firm fixed effects and HS2-by-year fixed effects are controlled. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level.

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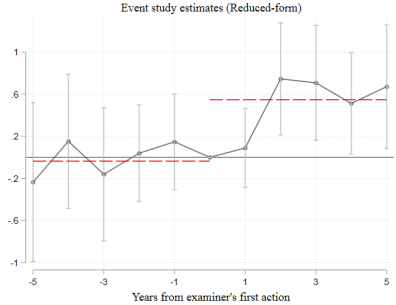

Note: The figure shows the event study plot of the reduced-form estimates of the effect of successful first U.S. patent application on export. The sample covers all CCTS-PAIR matched exporters. The dependent variable is log export value, and the regressors include the examiner's residualized approval rate interacted with time dummies. Firm fixed effects and HS2-by-year fixed effects are controlled. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level.

Placebo Test

Dependent variable	*Annualized 3-year export growth, 3-year lagged*		
	(1)	(2)	(3)
Successful first application	0.00381	0.0111	0.0134
	(0.00845)	(0.0222)	(0.0214)
Log export, 3-year lagged			-0.00953***
			(0.00146)
Export tenure, 3-year lagged			-0.00916***
			(0.00136)
Models	OLS	2SLS	2SLS
K-P rk Wald F-stats		151.84	150.17
Observations	947	947	947

Note: The table reports the estimated effect of successful first U.S. patent application on the 3-year lagged export growth of Chinese applicants as a placebo test. The dependent variable is annualized 3-year growth rate of export value, 3-year lagged. The sample includes all CCTS-PAIR matched exporters. HS2 by application year fixed effects are controlled in all columns. Columns 1 is estimated with OLS, and the rest are estimated with 2SLS, using the residualized examiner approval rates as instruments. Column 3 includes log initial export value and export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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The Effect of Second Application

Dependent variable: Annualized 3-year export growth			
	(1)	(2)	(3)
Successful second application	0.0250*	0.0215	0.0255
	(0.0139)	(0.0371)	(0.0344)
Log export			-0.00881***
			(0.00222)
Export tenure			-0.00191
			(0.00218)
Year fixed effects	Yes	Yes	Yes
Models	OLS	2SLS	2SLS
Sample		CCTS	
K-P rk Wald F-stats		40.56	41.92
Observations	409	409	409

Note: The table reports the estimated effect of successful second U.S. patent application on export growth of Chinese applicants. The dependent variable is annualized 3-year growth rate of export value. The sample includes all CCTS-PAIR matched exporters, and control for year fixed effects. Columns 1 is estimated with OLS, and the rest are estimated with 2SLS, using examiner approval rates as instruments. Column 3 includes log initial export value and export tenure as controls. Heteroskedasticity-consistent standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Alternative Specifications

Dependent variable	*Annualized 3-year export growth*					
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.178***	0.163***	0.253***	0.195***	0.175***	0.181***
	(0.0525)	(0.0544)	(0.0736)	(0.0515)	(0.0494)	(0.0490)
Log export	-0.0367***	-0.0367***	-0.0367***	-0.0377***	-0.0379***	-0.0398***
	(0.00492)	(0.00491)	(0.00499)	(0.00400)	(0.00405)	(0.00473)
Export tenure	-0.00297	-0.00310	-0.00243	-0.00239	-0.00161	-0.000482
	(0.00366)	(0.00364)	(0.00382)	(0.00294)	(0.00305)	(0.00381)
Log examined Chinese patents			0.00153			
			(0.0149)			
Log examined foreign patents			-0.0213			
			(0.0210)			
Log examiner experience			0.00213			
			(0.0279)			
Application year fixed effects				Yes		
First action year fixed effects					Yes	
HS2-application year fixed effects	Yes	Yes	Yes			
HS2-first action year fixed effects						Yes
Instrument	IV1	IV2	IV2	IV1	IV1	IV1
K-P rk Wald F-stats	193.92	213.10	93.73	187.22	182.46	154.86
Observations	1156	1156	1156	1282	1282	1171

Note: The table reports the estimated effect of successful first U.S. patent application on export growth of Chinese applicants, with alternative specifications. The dependent variable is annualized 3-year growth rate of export value. The sample covers all CCTS-PAIR matched exporters. Column 1 replicates the baseline estimate. Column 2 uses the alternative instrument that excludes both art unit by year fixed effects and technology class by year fixed effects. Column 3 add examiner characteristics as control variables. Column 4 to 6 experiment alternative fixed effects rather than HS2 by application year fixed effects. Column 4 includes application year fixed effects. Column 5 includes first action year fixed effects. Column 6 includes HS2 by first action year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Other Export Outcomes

Dependent variables	*Annualized 3-year growth of*			
	#Products	#Destinations	#Prod.-Dest. pairs	Average value
	(1)	(2)	(3)	(4)
Successful first application	0.0664	0.0552	0.0797*	0.116**
	(0.0414)	(0.0345)	(0.0407)	(0.0479)
Log export	-0.00183	-0.0128***	-0.0104***	-0.0372***
	(0.00329)	(0.00297)	(0.00361)	(0.00408)
Export tenure	-0.00442**	-0.00539**	-0.00624***	0.00288
	(0.00224)	(0.00212)	(0.00232)	(0.00310)
K-P rk Wald F-stats	193.92	193.92	193.92	193.92
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on other outcomes of Chinese applicants. The dependent variable is annualized 3-year growth rates of the export-related variables listed below. The sample covers all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using residualized examiner approval rates as instruments. HS2-application year fixed effects and control variables, including log initial export value and export tenure, are included in all columns. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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The Decomposition Method

The export growth rate can be decomposed into two components.

$$\begin{aligned}\Delta_k Export &\equiv \frac{Export_k - Export_0}{0.5(Export_k + Export_0)} \\ &= \underbrace{\frac{\sum_{\omega\in\Omega_0}(x_{\omega k} - x_{\omega 0})}{0.5(Export_k + Export_0)}}_{Incumbent\ Component} + \underbrace{\frac{\sum_{\omega\in\Omega_k\setminus\Omega_0} x_{\omega k}}{0.5(Export_k + Export_0)}}_{New\ Component}\end{aligned}$$

- **The "incumbent" component**: contribution of incumbent product-destination pairs
  - **The "continuing" component**: Value change of continuing product-destination pairs.
  - **The "drop" component**: Value destruction from dropped product-destination pairs.
- **The "new" component**: contribution of value creation from newly added product-destination pairs.

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Three-part Decomposition

Dependent variables	*Components of annualized 3-year export growth*							
	All	All	Continuing	Continuing	Drop	Drop	New	New
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Successful first application	0.174***	0.178***	0.0686*	0.0693**	-0.0870***	-0.0869***	0.0182	0.0216
	(0.0568)	(0.0525)	(0.0360)	(0.0351)	(0.0311)	(0.0309)	(0.0311)	(0.0262)
Log export		-0.0367***		-0.00978***		-0.00415*		-0.0311***
		(0.00492)		(0.00292)		(0.00241)		(0.00232)
Export tenure		-0.00297		-0.00243		-0.00237		-0.00290*
		(0.00366)		(0.00209)		(0.00204)		(0.00149)
K-P rk Wald F-stats	196.51	193.92	196.51	193.92	196.51	193.92	196.51	193.92
Observations	1156	1156	1156	1156	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column controls for HS2 by application year fixed effects. Column 2, 4, 6, and 8 include log initial export value and export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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ASIE Decomposition

Dependent variables	*Components of annualized 3-year export growth*					
	All	All	Existing	Existing	New	New
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.218***	0.204***	0.159**	0.155**	0.0595**	0.0490**
	(0.0692)	(0.0623)	(0.0627)	(0.0611)	(0.0287)	(0.0230)
Log export		-0.0460***		-0.0122**		-0.0338***
		(0.00596)		(0.00553)		(0.00323)
Export tenure		-0.0139***		-0.00706**		-0.00681***
		(0.00372)		(0.00332)		(0.00156)
Log employment		0.0294***		0.0109		0.0184***
		(0.00858)		(0.00721)		(0.00413)
Industry-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ownership-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
K-P rk Wald F-stats	150.44	159.58	150.44	159.58	150.44	159.58
Observations	941	941	941	941	941	941

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of CCTS-ASIE Chinese applicants. The sample includes all all CCTS-ASIE matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column controls for CIC2 by application year and ownership type by application year fixed effects. Column 2, 4, 6, and 8 include log initial export value, export tenure, log initial sales, log initial employment, and initial operating profit as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Firm-product-destination Level Outcomes

The first U.S. patent improves survival rates of incumbent export flows and value growth of continuing export flows.

Panel A.Product-destination analysis (survival and value growth)

Dependent variables	Survival indicator			Value growth		
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.0768***	0.129	0.149**	0.0218	0.0824	0.235***
	(0.0177)	(0.0812)	(0.0698)	(0.0143)	(0.0616)	(0.0823)
Product-destination controls	Product-destination level log export value and relative tenure					
Firm controls	Firm level log export value and export tenure					
HS6-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Model	OLS	IV	Weighted IV	OLS	IV	Weighted IV
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats		27.626	104.275		20.765	56.063
Observations	86681	86681	86681	38940	38940	38940

Panel B. Product-destination analysis (price and quantity growth)

Dependent variables	Price growth			Quantity growth		
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.0195	-0.0765	-0.00891	0.00875	0.135**	0.223**
	(0.0144)	(0.0736)	(0.0802)	(0.0176)	(0.0688)	(0.0925)
Product-destination controls	Product-destination level log export value and relative tenure					
Firm controls	Firm level log export value and export tenure					
HS6-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Model	OLS	IV	Weighted IV	OLS	IV	Weighted IV
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats		14.813	44.293		14.813	44.293
Observations	31320	31320	31320	31320	31320	31320

Note: The table reports the estimated effect of successful first U.S. patent application on the survival rates of incumbent product-destination pairs and the value growth rates of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 are estimated with OLS, and the rest are estimated with 2SLS, using the residualized examiner approval rates as instruments. Export shares of product-destination pairs are used as weights in Columns 3 and 6. All columns include HS6-by-year fixed effects and country-by-year fixed effects, and control for log product-destination export value, relative product-destination tenure, log firm export value, and firm's export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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The Weighting Algorithm

- The ALP weights are developed using the methodology from Lybbert and Zolas (2014).
  1. Compare keywords in 6-digit HS industry descriptions with keywords in patent abstracts.
  2. Tabulate the number of patents for each USPC/CPC to industry/product classification combination based on the m-to-m matches
  3. Re-weight the results using a modified Bayesian weighting scheme, the 'hybrid' weighting approach
     - It increases the weights of the specific matches and reduces the weights of the generalized matches
  4. For details, see Lybbert and Zolas (2014) and Goldschlag, Lybbert, and Zolas (2019).

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Export Growth by Types: Monopoly Power

Panel A. Growth rate by destination/product types

	By destinations		By Products	
	U.S.	ROW	Related	Unrelated
Successful First Application	0.163*	0.149***	0.191	0.179***
	(0.0882)	(0.0556)	(0.116)	(0.0607)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	948	1152	698	1121

Panel B. Growth rate by destination-product pair types

	U.S. + Related	U.S. + Unrelated	ROW + Related	ROW + Unrelated
Successful First Application	0.200	0.208**	0.0780	0.181***
	(0.191)	(0.0980)	(0.117)	(0.0639)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	448	878	678	1108

Note: The table reports the estimated effect of successful first U.S. patent application on export growth of each type of product-destination pairs. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Decomposition with Alternative Definition of Technology Relevance

Panel A. Decomposition by destination/product types

	By destinations		By Products	
	U.S.	ROW	Related	Unrelated
Successful First Application	0.0219	0.156***	0.0652**	0.113**
	(0.0249)	(0.0428)	(0.0295)	(0.0445)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types

	U.S. + Related	U.S. + Unrelated	ROW + Related	ROW + Unrelated
Successful First Application	0.0199	0.00196	0.0453*	0.111***
	(0.0149)	(0.0197)	(0.0243)	(0.0371)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Specification of the Within-firm Analysis

The specification is similar to Eckel et. al (2015):

$$y_{ipdt+k} = \beta_w \cdot \mathbb{1}(\text{Successful First Application} = 1)_{it} \cdot C(d) + \Phi_w X_{ipdt} + \eta_{i\tau} + \lambda_{p\tau} + \lambda_{d\tau} + \epsilon_{ipdt+k}$$

- p denotes HS6 products, d denotes destination countries.
- y_{ipdt+k} is the outcome variable
  - Survival dummy of incumbent pairs
  - Value growth of continuing pairs
- $C(d)$ is the destination characteristics (rule-of-law indices or IP rights indices)
- X_{ipdt} includes log initial product-destination pair export and relative export tenure of each product-destination pair. $\lambda_{p\tau}$ ($\lambda_{d\tau}$) is the HS6 (destination) by application year fixed effects. $\eta_{i\tau}$ is the firm fixed effects.
- Coefficient of interest: β_w.
  - Within-firm reallocation across destinations
- We perform subsample analysis for different product groups
  - Technologically relevant/irrelevant
  - Heterogeneous/homogeneous products

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Product-Destination Level Analysis: Alternative Definition of Technology Relevance

Product-destination level analysis: the monopoly power channel

	Value growth			Price growth		
Technology relatedness (alt.)	All	Yes	No	All	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application X U.S.	0.114	-0.0881	0.133	0.0489	-0.0283	0.0260
	(0.116)	(0.187)	(0.124)	(0.0651)	(0.144)	(0.0766)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
K-P rk Wald F-stats	6.89	13.14	5.51	6.29	13.63	4.96
Observations	38822	9168	28971	31222	7792	22871

Note: The table reports the heterogeneous effect of successful first U.S. patent application on the value and price growth of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 contain all continuing product-destination pairs of CCTS-PAIR matched exporters, columns 2 and 5 contain continuing pairs of products technologically related to the U.S. patent, and columns 3 and 6 contain continuing pairs of unrelated products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Export Growth by Types: Quality Signal

Panel A. Growth rate by destination/product types

	By destinations		By Products	
	High income	Low income	Differentiated	Non-differentiated
Successful First Application	0.119**	0.130	0.176***	0.128
	(0.0574)	(0.0866)	(0.0600)	(0.101)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1149	975	1075	793

Panel B. Growth rate by destination-product pair types

	HI+Diff.	HI+Non-diff.	LI+Diff.	LI+Non-diff.
Successful First Application	0.132**	0.115	0.0475	0.130
	(0.0651)	(0.101)	(0.0844)	(0.162)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1063	760	875	431

Note: The table reports the estimated effect of successful first U.S. patent application on export growth of each type of product-destination pairs. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Decomposition with Alternative Definition of Product Differentiation

Panel A. Decomposition by destination/product types

	By destinations		By Products	
	High income	Low income	High CV	Low CV
Successful First Application	0.129***	0.0485**	0.159***	0.0240
	(0.0458)	(0.0243)	(0.0476)	(0.0161)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types

	HI+High CV	HI+Low CV	LI+High CV	LI+Low CV
Successful First Application	0.120***	0.0140	0.0390*	0.00982
	(0.0429)	(0.0105)	(0.0225)	(0.00929)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Product-Destination Level Analysis: Alternative Definition of Product Differentiation

Product-destination level analysis: the quality signal channel

	Survival Indicator			Value growth		
High Price CV	All	Yes	No	All	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application X ln(GDP per capita)	0.0206*	0.0229**	-0.00486	0.00304	0.00544	-0.0804
	(0.0120)	(0.0113)	(0.0512)	(0.0195)	(0.0193)	(0.0873)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats	32.30	26.52	50.70	20.85	18.11	17.26
Observations	85955	75925	9355	38665	34330	3957

Note: The table reports the heterogeneous effect of successful first U.S. patent application on the value and price growth of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 contain all continuing product-destination pairs of CCTS-PAIR matched exporters, columns 2 and 5 contain continuing pairs of products technologically related to the U.S. patent, and columns 3 and 6 contain continuing pairs of unrelated products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Export Growth by Types: Contractual Signal

Panel A. Growth rate by destination/product types

	By destinations		By Products	
	High RLI	Low RLI	High Contract Int.	Low Contract Int.
Successful First Application	0.147***	0.111	0.144***	0.201**
	(0.0549)	(0.0921)	(0.0554)	(0.0932)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Growth rate by destination-product pair types

	HRLI+High CI	HRLI+Low CI	LRLI+High CI	LRLI+Low CI
Successful First Application	0.115**	0.200**	0.0934	0.240*
	(0.0580)	(0.0972)	(0.0991)	(0.144)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on export growth of each type of product-destination pairs. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Decomposition with Alternative Definition of Contractual Intensity

Panel A. Decomposition by destination/product types

	By destinations		By Products	
	High RLI	Low RLI	More Upstream	Less Upstream
Successful First Application	0.151***	0.0277	0.0920***	0.0863**
	(0.0463)	(0.0232)	(0.0311)	(0.0421)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types

	HRLI+More Up.	HRLI+Less Up.	LRLI+More Up.	LRLI+Less Up.
Successful First Application	0.0772***	0.0737*	0.0148	0.0130
	(0.0281)	(0.0394)	(0.0113)	(0.0163)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first U.S. patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PAIR matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Product-Destination Level Analysis: Alternative Definition of Contractual Intensity

Product-destination level analysis: the contractual signal channel

	Survival Indicator			Value growth		
Contract Intensity	All	High	Low	All	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × Rule-of-law Index	0.0307**	0.0452*	0.0219	0.00529	0.0252	-0.00696
	(0.0150)	(0.0244)	(0.0146)	(0.0244)	(0.0460)	(0.0233)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats	25.73	34.70	18.34	17.23	12.84	14.43
Observations	86319	32302	53548	38752	13334	24970

Note: The table reports the heterogeneous effect of successful first U.S. patent application on the value and price growth of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 contain all continuing product-destination pairs of CCTS-PAIR matched exporters, columns 2 and 5 contain continuing pairs of products technologically related to the U.S. patent, and columns 3 and 6 contain continuing pairs of unrelated products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Testing the Financial Constraint Mechanism

Dependent variable	*Annualized 3-year export growth*					
Financial Constraint Proxies	*Ext.Fin. Dependence*		*Liquidity Needs*		*Tangibility*	
Firm group	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(7)	(8)
Successful first application	0.150**	0.187***	0.154**	0.234***	0.138**	0.268***
	(0.0682)	(0.0621)	(0.0619)	(0.0772)	(0.0660)	(0.0823)
Difference (High - Low)	-0.0368		-0.799		-0.130	
	(0.0894)		(0.0971)		(0.0999)	
Custom controls	Log export, export tenure					
HS2-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample	CCTS					
K-P rk Wald F-stats	147.46	135.58	180.43	101.28	138.46	102.99
Observations	473	644	646	470	591	511

Note: The table reports the estimated effect of successful first U.S. patent application on export growth of Chinese applicants with different levels of measured financial constraints. The dependent variable is annualized 3-year growth rate of export value. The sample covers all CCTS-PAIR matched exporters, divided by the sample median of measured financial constraints. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Control variables including log initial export value and export tenure and HS2 by application year fixed effects are included in all columns. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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Patent Filing in China

Depedent variables:	1-year patent growth		3-year patent growth	
	(1)	(2)	(3)	(4)
Successful first application	0.0207	0.00700	0.382	0.754
	(0.179)	(0.384)	(0.298)	(0.737)
Log patent	-0.191***	-0.191***	-0.209*	-0.208*
	(0.0479)	(0.0486)	(0.108)	(0.113)
Application year fixed effects	Yes	Yes	Yes	Yes
Model	OLS	IV	OLS	IV
K-P rk Wald F-stats		55.589		37.686
Observations	244	244	111	111

Note: The table reports the estimated effect of successful first U.S. patent application on subsequent patent applications in China. The sample includes all all CCTS-ASIE-SIPO-PAIR matched exporters. Columns 1 and 3 are estimated with OLS. Columns 2 and 4 are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include application year fixed effects, and control for log patent applications in China in the year of first U.S. patent application. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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