

Trade with Benefits: New Insights on Competition and Innovation

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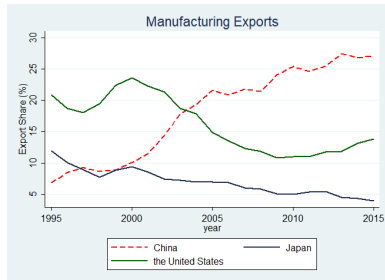
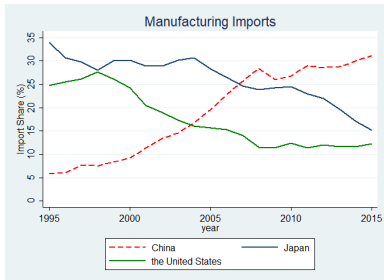
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- **How does trade with China, both import and export channels, affect the innovation outcomes of Korean manufacturing firms?**
- **How are the impacts different according to the type or sector of the firms?**

Motivation of the Research (1)

The rise of China in international trade have represented a **significant competition shock in Korea**.

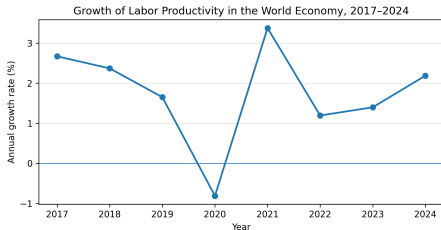
Figure 1: Major Trade Partners of Korea, 1995-2015



**Source: Authors' Calculation, BACI*

Motivation of the Research (2)

Figure 2: Growth of Labor Productivity in the World Economy, 1995-2024



Source: World Bank, World Development Indicators, GDP per person employed (constant 2021 PPP \$), indicator SL.GDP.PCAPEM.KD. Growth rates calculated by author.

**Source: World Bank, WDI.*

- **The importance of innovation:** One of the potential solutions to the global productivity slow down is the innovation. Also, innovation is closely related to the profits and survival of a firm (Atalay et al., 2013; Tavassoli and Karlsson, 2016). So, innovation is one of the rising topic in policy research.

Motivation of the Research (3)

- The global trade environment has shifted from simple market integration toward **geoeconomic fragmentation**: tariffs, export controls, industrial policy, and supply-chain security concerns increasingly shape trade flows.
- In particular, U.S.–China strategic competition has made trade with China not only a source of market opportunity and competition, but also a channel of policy uncertainty and technology restrictions.
- Recent Middle East tensions also highlight how geopolitical shocks can disrupt energy, shipping, and input costs, reinforcing the importance of firm-level resilience and innovation capacity.

Intuition between Trade and Innovation

- **(Import)** More imports in the market would create the competition, and this may push the existing firm to innovate. **(Export)** The export market, such as China, gives more opportunities to the firms to expand their business, and it may increase the profit of the firm, which eventually could lead to innovation.
- However, the question is not easy to analyze because firms may react differently to import and export competition. It is because there are **two opposing effects** in the relationship, which are '*Schumpeterian force*' and '*escaping competition*' (Aghion et al., 2005).
- So, this empirical research aims to understand the complex nature of innovation and competition relationship through the case of Korea and China Trade. Also, we aim to identify the firm's motives such as '*Schumpeterian force*' and '*escaping competition.*' based on our comprehensive dataset.

Preview of the Findings (1)

- First, trade with China, both import and export channels, is **positively** associated with innovation responses of Korean firms. 10% increase in trade with China will boost the number of the patent about 1.5%.
- Second, we found that the positive impacts are different by the types of a firm, such that **listed or large firms would produce more innovation** from the trade with China than non-listed or SMEs.
- Third, Korean manufacturing firms in the **high-quality sector** (compared to China) would experience the positive impact of China shock from trade on their innovation response. However, there is negative, but no significant impact in the low-quality sectors.

Preview of the Findings (2)

- The firms in low-quality sectors are more likely to face direct competition with Chinese products both home and abroad markets than the firms in high-quality sectors. *Chinese products are more labor-intensive product than the product of the advanced economies, and the firms in low-quality sectors produce more labor-intensive products compared to the firms in high-quality sectors.*
- So, our results suggest that ‘escape competition’ motive would prevail when the firms are insulated from direct competition with China whereas ‘Schumpeterian force’ motive would dominate if firms face competition from China more directly.

Contribution of the Research

- To our knowledge, this paper is the first study to analyze how trade with China affects the innovation outcome of Korean firms using the **patent data**.
- There are two potential channels between trade induce competition and innovation. However, previous literatures in this topics are mostly focused on the import side of the story. By including the **export channel** in the analysis, we expand the analysis of the previous literature.
- Our empirical research also contributes the unique finding to the literature that the impact of competition on the innovation depends on the firm's capacity and sectoral differences. Our research relates to 'escaping competition' motive in high-quality sectors (Aghion et al. , 1997; 2005) and to 'Schumpeterian' force in low-quality sectors (Aghion and Howitt, 1992). Our result **reconciles the conflicting results from the previous literature**.

Our empirical analysis is based on firm-level data of Korean manufacturing firms in 1996–2015 (20 years).

- Firm-level data is from KIS-Value by NICE Inc. The data is collected annually from all Korean companies with assets over 7 billion won (7 million dollars).
- Patent data is from KIPRIS (Korea Intellectual Property Rights Information Service), which is an official provider of firm-level patent information.
- Trade data is from BACI by CEPII. Compared to raw data from COMTRADE, BACI data has an advantage because it resolves the issue of unmatching value between imports with CIF (cost, insurance, and freight) and exports with FOB (free on board) value.

Data Harmonization

Each dataset follows different types of industry classification. The harmonization is based on **ISIC Rev.3** at the four-digit level.

- Industry classification of BACI data follows HS 92 \Rightarrow WB WITS Corresponding Table (From HS92 to ISIC Rev3).
- Industry classification of KIS-Value Firm data and Patent data follow KSIC-9. However, KSIC-9 is modified from ISIC Rev.4. KSIC-9 it has more detailed classifications than ISIC Rev.4. \Rightarrow [1] Manual matching of industry between KSIC-9 and ISIC Rev.4, then [2] a UN Corresponding Table (from ISIC Rev.4 to ISIC Rev.3.1) *4-digit level of ISIC Rev 3.1 and ISIC Rev.3 is identical.

Table 1: Example of Industry Classification in ISIC Rev.4 and KSIC-9

ISIC Rev.4	KSIC-9
Manufacture of wearing apparel, except fur apparel (1410)	Outer (1411) Inner wear (1412) Korean traditional clothing (1413) Other wearing apparel (1414)

Source: UN Statistics Division and KOSTAT

Data Innovation Outcome (1)

- Our paper exploits the **patent data** to measure the innovation outcome (Griliches, 1990; Nagaoka et al., 2010; Acemoglu and Akcigit, 2012).
- Yearly patent data is a **reasonable proxy of an innovative activity** for the year in which the invention occurs. It provides detailed information of the patent application, such as the technology class of the patent(IPC), the name and address of the inventors, and the granted status of the patent applications.
- Matching patent data to firm data is a challenging task. [1] The KIPRIS patent database does not allow people to search the data with a corporate registration number. ⇒ **search by the name of a firm**. Moreover, applicant numbers for identical applicants are not always the same unless their names are perfectly identical. [2] A user can retrieve patent data up to 5,000 per query. ⇒ **automatic algorithm by R and Stata codings**

Data Innovation Outcome (2)

- To circumvent this challenge, we develop an automated algorithm based on R coding to retrieve patent data by the name. The coding is devised to search each name of 11,000 firms from the database (through **Open-API access**) and to save the data into the Excel format. Then, we extract the exact patent information from the raw data and assign patent information to each firm in KIS-Value through STATA coding.
- We solve the issue of exceeding 5,000 results by altering the periods of the query; 20 years - 1 years - 6 month - 1 month - 2 weeks - 1 day.
- We succeed to retrieve patent information of (about) 11,000 firms from KIPRIS database.
- We build two innovation variables; **the number of patent applications** and **the number of patents granted**. The number of patents granted is a subset of the number of patent applications, in which a small number of patent applications are endowed with an exclusive right. From these two measurements, we can deliver more precise analysis by controlling the quality of patents.

Figure 3: China Trade and Innovation by Sector (ISIC rev.3, 2 digit)

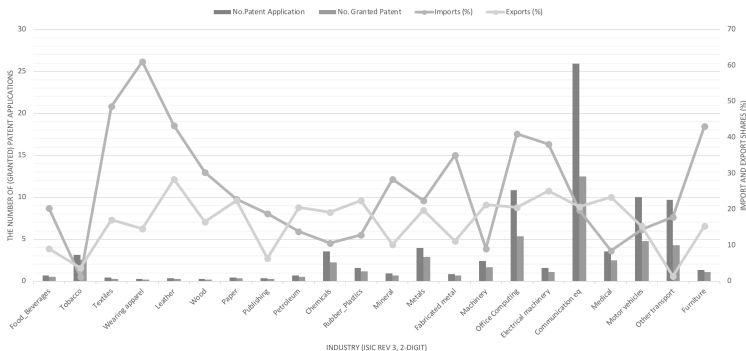


Figure 3 shows the average import, export exposures, the number of patent applications and granted patents. We find that the level of import/export competition and patenting activities are different across the sectors.

Table 2: Innovation: SMEs vs Large Firms

Year	Small-Medium sized Enterprises					Large Firms					
	(1) No. Firms	(2) No. Patenting Firm	(3)=(2)/(1) % of Patenting Firm	(4) No. Patent	(5) No. Granted Patent	(6) No. Firms	(7) No. Patenting Firm	(8)=(7)/(6) % of Patenting Firm	(9) No. Patent	(10) No. Granted Patent	
1996	3,138	267	8.51	1,426	896	907	210	23.15	52,063	18,399	
1997	3,458	339	9.80	1,685	1,092	1997	930	231	24.84	40,539	18,543
1998	3,828	424	11.08	1,664	1,194	1998	969	257	26.52	22,059	10,770
1999	4,378	635	14.50	2,323	1,921	1999	1,022	297	29.06	23,764	14,232
2000	4,990	937	18.78	3,817	3,099	2000	1,082	365	33.73	21,497	13,516
2001	5,404	1,125	20.82	4,320	3,645	2001	1,121	394	35.15	24,002	15,822
2002	5,803	1,204	20.75	4,540	3,849	2002	1,170	387	33.08	32,609	20,356
2003	6,146	1,292	21.02	4,993	4,360	2003	1,204	447	37.13	40,975	25,349
2004	6,494	1,461	22.50	5,832	5,061	2004	1,248	493	39.50	47,271	27,199
2005	6,845	1,694	24.75	6,442	5,914	2005	1,283	548	42.71	53,131	32,306
2006	7,164	1,812	25.29	7,109	6,518	2006	1,317	575	43.66	51,851	32,223
2007	7,265	1,824	25.11	7,150	5,774	2007	1,301	534	41.05	46,521	27,983
2008	7,507	1,871	24.92	7,998	6,177	2008	1,340	581	43.36	41,369	24,342
2009	7,764	2,092	26.94	8,762	6,938	2009	1,381	617	44.68	35,799	21,968
2010	8,087	2,131	26.35	8,437	6,719	2010	1,397	622	44.52	38,703	23,162
2011	8,357	2,267	27.13	9,016	7,215	2011	1,428	648	45.38	40,850	17,208
2012	8,636	2,395	27.73	10,017	8,194	2012	1,457	649	44.54	45,473	17,166
2013	8,794	2,461	27.98	10,143	8,184	2013	1,473	667	45.28	48,320	17,185
2014	8,808	2,443	27.74	10,094	7,535	2014	1,473	617	41.89	47,110	16,467
2015	8,668	2,269	26.18	9,994	6,420	2015	1,412	594	42.07	43,832	11,033

Source: Authors' calculation, KIS-Value and KIPRIS

Table 1 shows the share of patenting firms and a number of a patent based on the size of firms. Large firms are more active in patenting and have more patent applications compared to the SMEs.

Table 3: Innovation: Listed vs Non-Listed Firms

Non-Listed Firms						Listed Firms					
Year	(1) No. Firms	(2) No. Patenting Firm	(3)=(2)/(1) % of Patenting Firm	(4) No. Patent	(5) No. Granted Patent	Year	(6) No. Firms	(7) No. Patenting Firm	(8)=(7)/(6) % of Patenting Firm	(9) No. Patent	(10) No. Granted Patent
1996	3,346	282	8.43	1,201	818	1996	699	195	27.90	52,288	18,477
1997	3,652	349	9.56	1,579	1,146	1997	736	221	30.03	40,645	18,489
1998	4,013	439	10.94	2,168	1,437	1998	784	242	30.87	21,555	10,527
1999	4,545	622	13.69	2,668	2,056	1999	855	310	36.26	23,419	14,097
2000	5,127	903	17.61	3,806	3,182	2000	945	399	42.22	21,508	13,433
2001	5,548	1,083	19.52	4,573	3,766	2001	977	436	44.63	23,749	15,701
2002	5,956	1,148	19.27	4,845	4,018	2002	1,017	443	43.56	32,304	20,187
2003	6,308	1,241	19.67	7,072	5,507	2003	1,042	498	47.79	38,896	24,202
2004	6,661	1,415	21.24	8,791	6,359	2004	1,081	539	49.86	44,312	25,901
2005	7,026	1,646	23.43	10,088	7,847	2005	1,102	596	54.08	49,485	30,373
2006	7,357	1,760	23.92	10,908	8,651	2006	1,124	627	55.78	48,052	30,090
2007	7,455	1,754	23.53	9,906	6,945	2007	1,111	604	54.37	43,765	26,812
2008	7,714	1,834	23.77	11,235	7,617	2008	1,133	618	54.55	38,132	22,902
2009	8,010	2,068	25.82	10,828	7,884	2009	1,135	641	56.48	33,733	21,022
2010	8,316	2,088	25.11	10,704	7,828	2010	1,168	665	56.93	36,436	22,053
2011	8,619	2,215	25.70	11,241	8,003	2011	1,166	700	60.03	38,625	16,420
2012	8,911	2,351	26.38	14,246	9,256	2012	1,182	693	58.63	41,244	16,104
2013	9,073	2,414	26.61	16,034	9,442	2013	1,194	714	59.80	42,429	15,927
2014	9,098	2,365	25.99	14,858	8,262	2014	1,183	695	58.75	42,346	15,740
2015	8,953	2,194	24.51	14,940	6,794	2015	1,127	669	59.36	38,886	10,659

Source: Authors' calculation, KIS-Value and KIPRIS

We also find that listed firms are more active in patenting and have more patent applications compared to the non-listed firms.

$$INNV_{ijt} = \beta_0 + \beta_1 IMP_{jt-1}^{CHN} + \beta_2 EXP_{jt-1}^{CHN} + \beta_3 X_{ijt} + Trends_j + FE_i + FE_t + \epsilon_{ijt} \quad (1)$$

where the panel is constructed in a firm 'i', corresponding to a sector 'j' in 4-digit ISIC rev.3 industry and a year 't'.

- $INNV_{ijt}$: Innovation outcome; the number of patent application and the number of granted patent.
- IMP_{jt-1}^{CHN} : Import exposure in a sector j at time t-1 ; the share of imports from China over total imports in Korea.
- EXP_{jt-1}^{CHN} : Export exposure in a sector j at time t-1 ; the share of export to China over total export in Korea.
- X_{ijt} : Innovation capacity of a firm i in sector j at time t; age, capital, sales, and the number of employees.
- Included in the fixed effects are firm FE (FE_i), and year FE (FE_t), and we control for the industry trends of the ISIC Rev.3 at the four-digit level ($Trends_j$)

$$\begin{aligned} INNV_{ijt} = & \beta_0 + \beta_1 IMP_{jt-1}^{CHN} + \beta_2 EXP_{jt-1}^{CHN} + \beta_3 D_FIRM_{ijt} \\ & + \beta_4 IMP_{jt-1}^{CHN} * D_FIRM_{ijt} + \beta_5 EXP_{jt-1}^{CHN} * D_FIRM_{ijt} \quad (2) \\ & + \beta_6 X_{ijt} + Trends_j + FE_i + FE_t + \epsilon_{ijt} \end{aligned}$$

The characteristics included (D_FIRM_{ijt}) are as follows.

- (1) Listed: If a firm is in the public trading market, we classify the firm as “listed,” and we assign 1 to the dummy.
- (2) Size: If the number of employees is greater than 100, we classify the firm as a large-sized firm, and we assign 1 to the dummy.
- (3) Age: If the age of a firm is less than five years, we classify the firm as a young firm, and we assigned 1 to the dummy.
- (4) Domestic: If a firm does not report a cost of export within the entire data period, we classify the firm as a domestic firm, and we assign 1 to the dummy.

Following the work of Schott (2004) and Hallak (2006), we classify the sector by product quality.

- We calculate the **export unit price** of Korea and China for each sector. We divide the export value (thousand USD) by each sectoral unit (ton). The export unit price indicates the average value of products in each sector.
- We compare the sectoral quality of a product by comparing the unit price between China and Korea based on the 1995 BACI trade data. We divide the manufacturing sector into the high-quality sector and the low-quality sector.
- The differentiation allows us to unravel the ambiguous relationship in competition and innovation, such that we aim to identify the 'Schumpeterian force' and 'escaping competition force' by the level of competition in each sector.

- The import and export variables may correlate with unobservable technology shock or industry shock. For instance, imports from China may increase from domestic demand in low-cost Chinese products. Exports to China also vary according to the industry shocks in the domestic market.
- To overcome the endogeneity issues in both import and export variables, we make use of **China's global exports**, and **China's global imports as instrumental variables** respectively.
- The rationale behind the instrumental variables is following. (**Import Variable**) The expansion of China's export supply in the world is positively correlated with Korea's imports from China, whereas China's world export supplies are not driven by the import demand of Korea, but by increasing Chinese comparative advantage from a productivity shock (Autor et al.,2013) \Rightarrow Supply vs. Demand.

Table 4: Baseline IV Results

	First Stage		Patent			(Granted) Patent		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SUP_CHN	0.330*** (0.013)							
DEM_CHN		0.436*** (0.017)						
IMP_CHN			0.101*** (0.038)		0.158*** (0.053)	0.114*** (0.036)		0.176*** (0.050)
EXP_CHN				0.064** (0.027)	0.117*** (0.040)		0.070*** (0.025)	0.129*** (0.037)
Observations	91587	91587	91587	91587	91587	91587	91587	91587
F	685.27	669.28						

* The dependent variables in the regression are the number of the patent application, granted patent plus 1 in logarithm. Firm control variables are the age, number of employees, sales, and capital of a firm. Firm FE Year FE and sector trends are included. All variables are in logarithm. Standard errors are clustered on firms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Baseline IV Results: Firm Characteristics

	Patent				(Granted) Patent			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IMP_CHN	0.110** (0.052)	0.126** (0.053)	0.158*** (0.053)	0.162*** (0.053)	0.140*** (0.050)	0.151*** (0.050)	0.177*** (0.050)	0.176*** (0.050)
EXP_CHN	0.079* (0.041)	0.068* (0.041)	0.120*** (0.040)	0.101** (0.042)	0.108*** (0.039)	0.087** (0.038)	0.133*** (0.038)	0.121*** (0.039)
IMP_CHN*Listed	0.115*** (0.020)				0.100*** (0.018)			
EXP_CHN*Listed	0.068* (0.035)				0.025 (0.031)			
IMP_CHN*Size		0.047*** (0.010)				0.033*** (0.008)		
EXP_CHN*Size		0.106*** (0.017)				0.091*** (0.015)		
IMP_CHN*Age			0.001 (0.009)				0.002 (0.008)	
EXP_CHN*Age			-0.012 (0.019)				-0.014 (0.017)	
IMP_CHN*Domestic				-0.003 (0.013)				0.005 (0.012)
EXP_CHN*Domestic				0.036 (0.025)				0.020 (0.022)
Observations	91587	91587	91587	91587	91587	91587	91587	91587

* The dependent variable in the regression is the number of the patent application and granted patent plus 1 in logarithm. Firm control variables are the age, number of employees, sales, and capital of a firm. Firm FE Year FE and sector trends are included. All variables are in logarithm. Standard errors are clustered on firms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Baseline IV Results: Quality

	Higher Quality Sector		Other Sector	
	(1) Patent	(2) (Granted)Patent	(3) Patent	(4) (Granted)Patent
IMP_CHN	0.481*** (0.153)	0.452*** (0.146)	-0.651 (1.394)	-0.036 (0.595)
EXP_CHN	0.236*** (0.067)	0.224*** (0.063)	-1.037 (2.133)	-0.126 (0.899)
Observations	62981	62981	28606	28606

* The dependent variable in the regression is the number of the patent application and granted patent plus 1 in logarithm. Firm control variables are the age, number of employees, sales, and capital of a firm. Firm FE Year FE and sector trends are included. All variables are in logarithm. Standard errors are clustered on firms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Baseline IV Results: Quality, Patent

	Higher Quality Sector				Other Sector			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IMP_CHN	0.398*** (0.151)	0.409*** (0.152)	0.478*** (0.153)	0.481*** (0.153)	-1.209 (2.988)	-0.878 (1.878)	-0.646 (1.376)	-0.561 (1.251)
EXP_CHN	0.179*** (0.067)	0.159** (0.067)	0.233*** (0.067)	0.225*** (0.069)	-1.956 (4.861)	-1.368 (2.962)	-1.031 (2.102)	-1.003 (2.026)
IMP_CHN*Listed	0.084*** (0.027)				0.138* (0.081)			
EXP_CHN*Listed	0.102** (0.043)				0.429 (0.942)			
IMP_CHN*Size		0.023** (0.011)				0.091** (0.044)		
EXP_CHN*Size		0.147*** (0.024)				0.119 (0.178)		
IMP_CHN*Age			0.006 (0.009)				-0.020 (0.067)	
EXP_CHN*Age			0.006 (0.028)				-0.029 (0.043)	
IMP_CHN*Domestic				0.002 (0.016)				-0.056 (0.091)
EXP_CHN*Domestic				0.024 (0.029)				0.115 (0.124)
Observations	62981	62981	62981	62981	28606	28606	28606	28606

* The dependent variable in the regression is the number of the patent application plus 1 in logarithm. Firm control variables are the age, number of employees, sales, and capital of a firm. Firm FE Year FE and sector trends are included. All variables are in logarithm. Standard errors are clustered on firms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Baseline IV Results: Quality, (Granted) Patent

	Higher Quality Sector				Other Sector			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IMP_CHN	0.387*** (0.144)	0.391*** (0.144)	0.450*** (0.146)	0.451*** (0.146)	-0.188 (0.889)	-0.152 (0.719)	-0.037 (0.591)	0.038 (0.562)
EXP_CHN	0.180*** (0.063)	0.156** (0.063)	0.223*** (0.063)	0.223*** (0.065)	-0.328 (1.432)	-0.273 (1.122)	-0.130 (0.891)	-0.057 (0.898)
IMP_CHN*Listed	0.070*** (0.025)				0.092** (0.037)			
EXP_CHN*Listed	0.079** (0.039)				0.014 (0.283)			
IMP_CHN*Size		0.013 (0.010)				0.070*** (0.024)		
EXP_CHN*Size		0.129*** (0.022)				0.041 (0.070)		
IMP_CHN*Age			0.006 (0.008)				-0.017 (0.037)	
EXP_CHN*Age			0.001 (0.025)				-0.017 (0.022)	
IMP_CHN*Domestic				0.013 (0.014)				-0.008 (0.047)
EXP_CHN*Domestic				0.004 (0.026)				0.065 (0.063)
Observations	62981	62981	62981	62981	28606	28606	28606	28606

* The dependent variable in the regression is the number of the granted patent plus 1 in logarithm. Firm control variables are the age, number of employees, sales, and capital of a firm. Firm FE Year FE and sector trends are included. All variables are in logarithm. Standard errors are clustered on firms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

- We start the research to understand **how the China shock in trade affects the innovation outcome of Korean manufacturing firms.**
- Based on our comprehensive data, we find the **positive impact** of imports and export competition on the innovation outcomes of Korean manufacturing firms. Also, the evidence suggests that the impacts depend on **the firms' characteristics and the sector they belong.**
- The heterogenous evidence suggests that Korean firms are likely to innovate when the firms are insulated from direct competition from China (**escaping competition**), and firms are less likely to innovate when firms face competition from China more directly (**Schumpeterian force**).

- The current policy environment is increasingly characterized by protectionism, strategic competition, export controls, and supply-chain security concerns, rather than by trade liberalization alone.
- Many economists worry about protectionism in trade, and policy institutions like IMF and WTO start reinvestigating the benefits of trade in respect to productivity, and innovation.
- Our research is in the line of this recent development of research.
- Our findings suggest that trade can stimulate innovation, but the gains are uneven across firms. Larger and listed firms appear better positioned to transform trade shocks into innovative outcomes.

- Therefore, policy should not only preserve the benefits of open trade, but also strengthen firms' innovation capacity, especially for SMEs and non-listed firms that may face stronger adjustment costs.
- So, providing a **safety net for the SMEs or non-listed firms**. The **inclusive policy** is needed
- Also, as we face a more fragmented global economy, export diversification, technology upgrading, and supply-chain resilience should be considered together with innovation policy. We leave these issues for future research.

Thank you.