Offshoring Bias in Productivity Estimates: Evidence from Japanese Customs Data

Prepared for the World KLEMS Tokyo Conference
2025/3/27

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This study is an outcome of the research conducted jointly with the Policy Research Institute (PRI) after submitting a request for use of customs' export and import declaration data to the Ministry of Finance (MOF) based on the ''Guideline on the utilization of customs' import and export declaration data in a joint research with Policy Research Institute,'' and receiving approval in Mar 2023. The views expressed in this study are those of the authors' personal responsibility and do not represent the official views of MOF or PRI.

Motivation

- There have been a lot of discussion on the impact of GVC participation on firm-level productivity.
- In the manufacturing sector, the import share[1] is almost 30% in 2021, which implies the importance of offshoring.

- Firms' effort to import cheap intermediate inputs causes a bias in the standard productivity estimates, i.e., "offshoring bias."
- This study aims to quantify the offshoring bias by uniquely utilizing the granular customs data from Japan.

1 The import share is defined as the share of imported goods and services out of total intermediate inputs.

Literature

- Diewert and Nakamura (2011), Houseman et al. (2011)
- Fukao and Arai (2015), Reinsdorf and Yuskavage (2018)

- **<u>This paper</u>**
  1. Quantify the offshoring bias by using the granular customs data
  2. Find that the offshoring bias is increasing in the import share

  → It implies the "import premium" in productivity could be due to the overestimation of firm-level productivity

Data

1. Japanese customs data
   - Granular trade data provided by the Ministry of Finance
   - All transactions between 2015 and 2020 at HS 9-digit level

2. Basic Survey of Japanese Business Structure and Activities
   - Annually conducted by the Ministry of Economy, Trade and Industry
   - Firms with 50 or more employees are covered in this survey
   - We can observe firm characteristics (sales, employment, intermediate inputs, R&D, etc.)

How to quantify the offshoring bias?

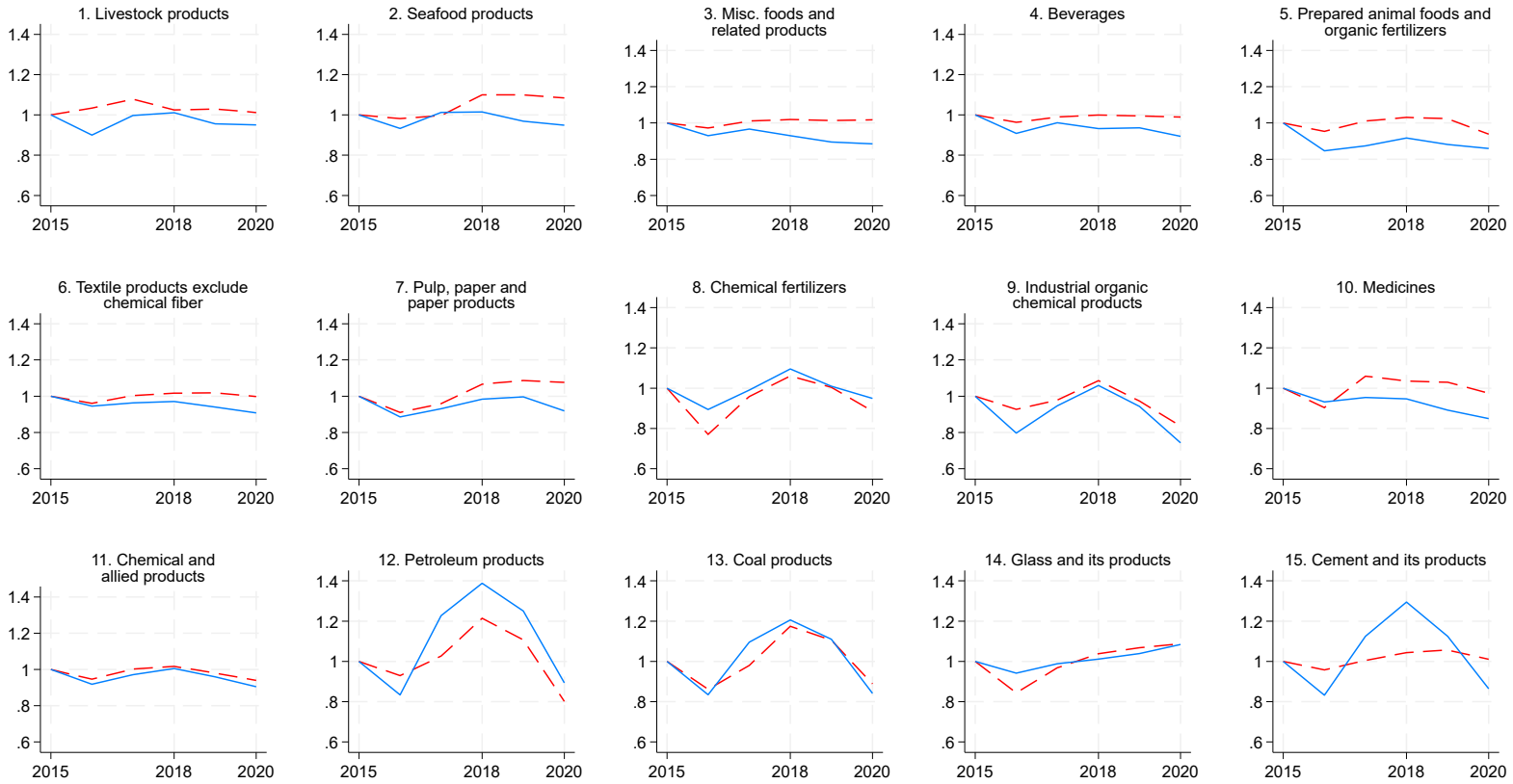
- We quantify the offshoring bias with 3 steps
  1. Construct 2 deflators: one dealing with the total intermediate inputs, and the other dealing separately with domestic and importing inputs
  2. Obtain 2 productivity estimates based on 2 different deflators
  3. Calculate TFP growth rates & define the gap in growth rates as offshoring bias

(1) Construction of 2 deflators

1. Construction of JIP intermediate input deflator for each industry
2. Construction of deflators for imported intermediate inputs for each firm
   a. We created deflators for imported intermediate inputs by assigning 3-digit level import deflators from the JIP Database to HS 9-digit level import value data.

- We also calculated average value of firm-level deflators for imported intermediate inputs across all firms in each industry. And we compare them with JIP intermediate input deflator.

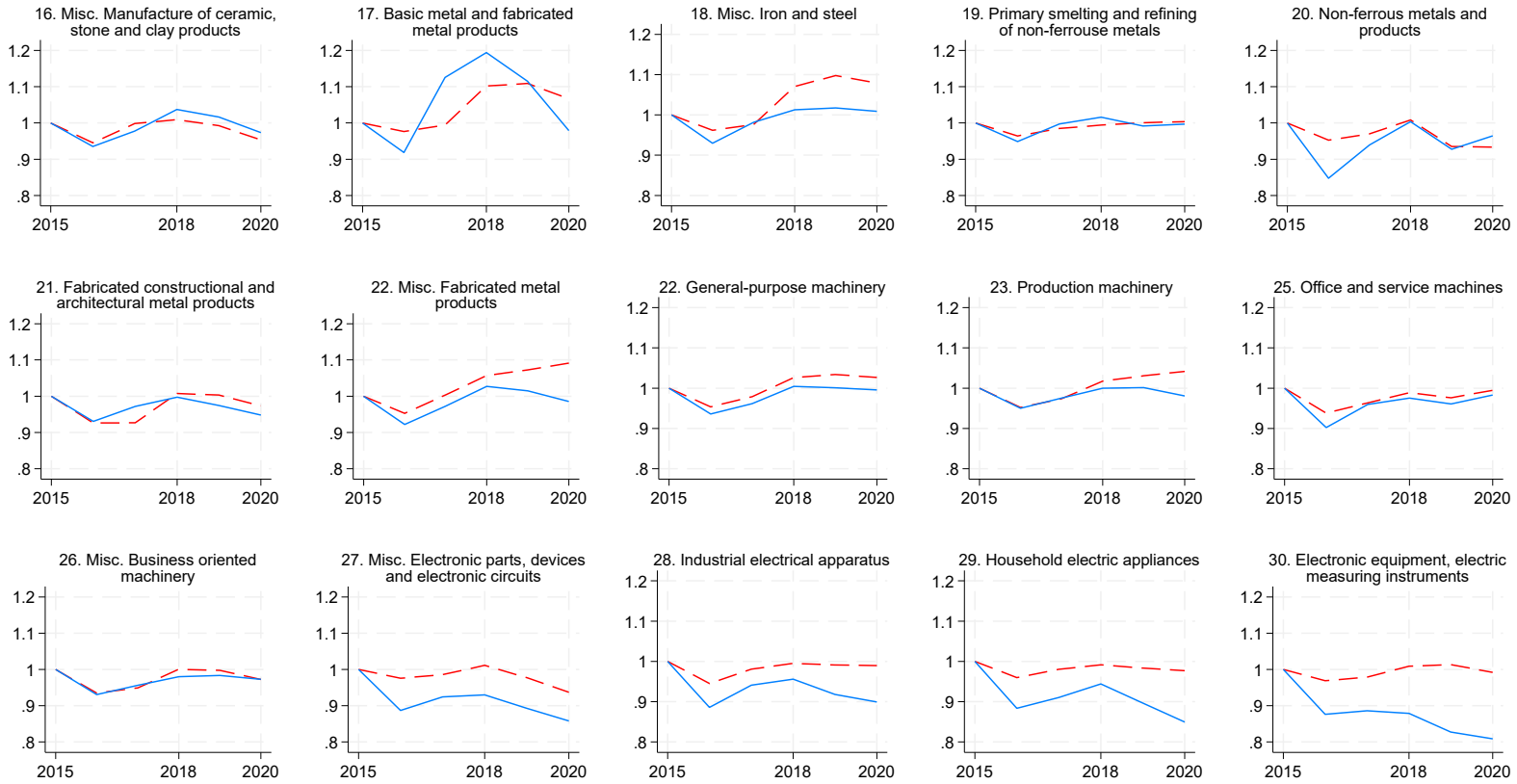
Divergence of 2 deflators



JIP intermediate input deflator (2015=1)

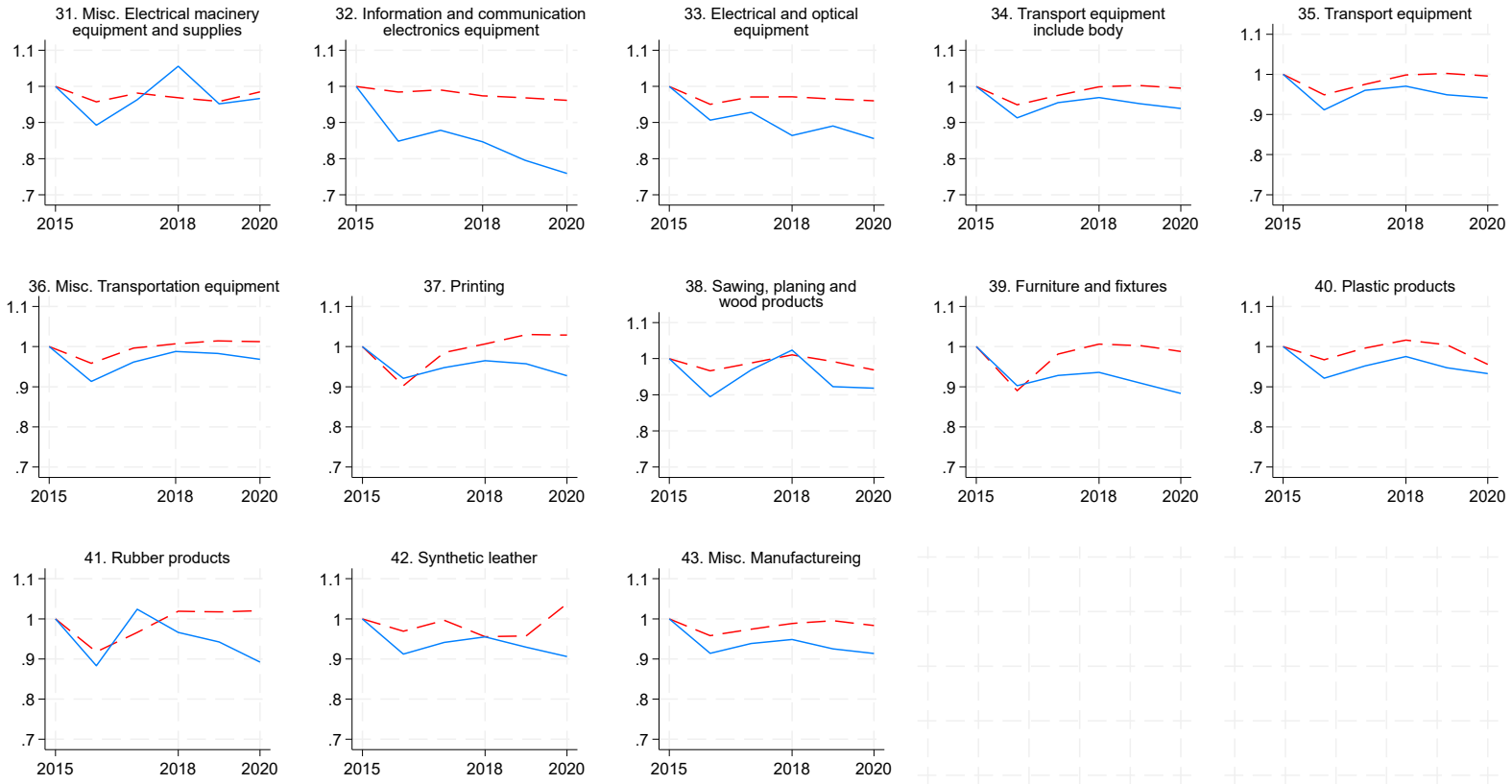
deflator for imported intermediate inputs (2015=1)

Divergence of 2 deflators



JIP intermediate input deflator (2015=1) deflator for imported intermediate inputs (2015=1)

Divergence of 2 deflators



(2) 2 estimates of firm-level TFP

1. The **index method** following Good, Nadiri and Sickles (1999)
   - It measures the productivity level of each firm, relative to a hypothetical representative firm in each industry in the base year (2015).

2. Production function estimation following **Wooldridge (2009)**[2]
   - It is based on the GMM estimation.
   - Intermediate inputs are calculated by taking firm's cost of goods sold minus selling and general administrative expenses, total payroll, and depreciation.

2 Note that this estimation method does not distinguish residuals and TFP estimates.

(3) TFP growth difference

- We obtain 2 versions of TFP estimate:
  1. Apply the JIP deflator to the total amount of intermediate inputs
  2. Use the deflators for imported intermediate inputs for each firm, which is based on 9-digit level customs data of that firm and separately apply 2 deflators for domestic and imported inputs.

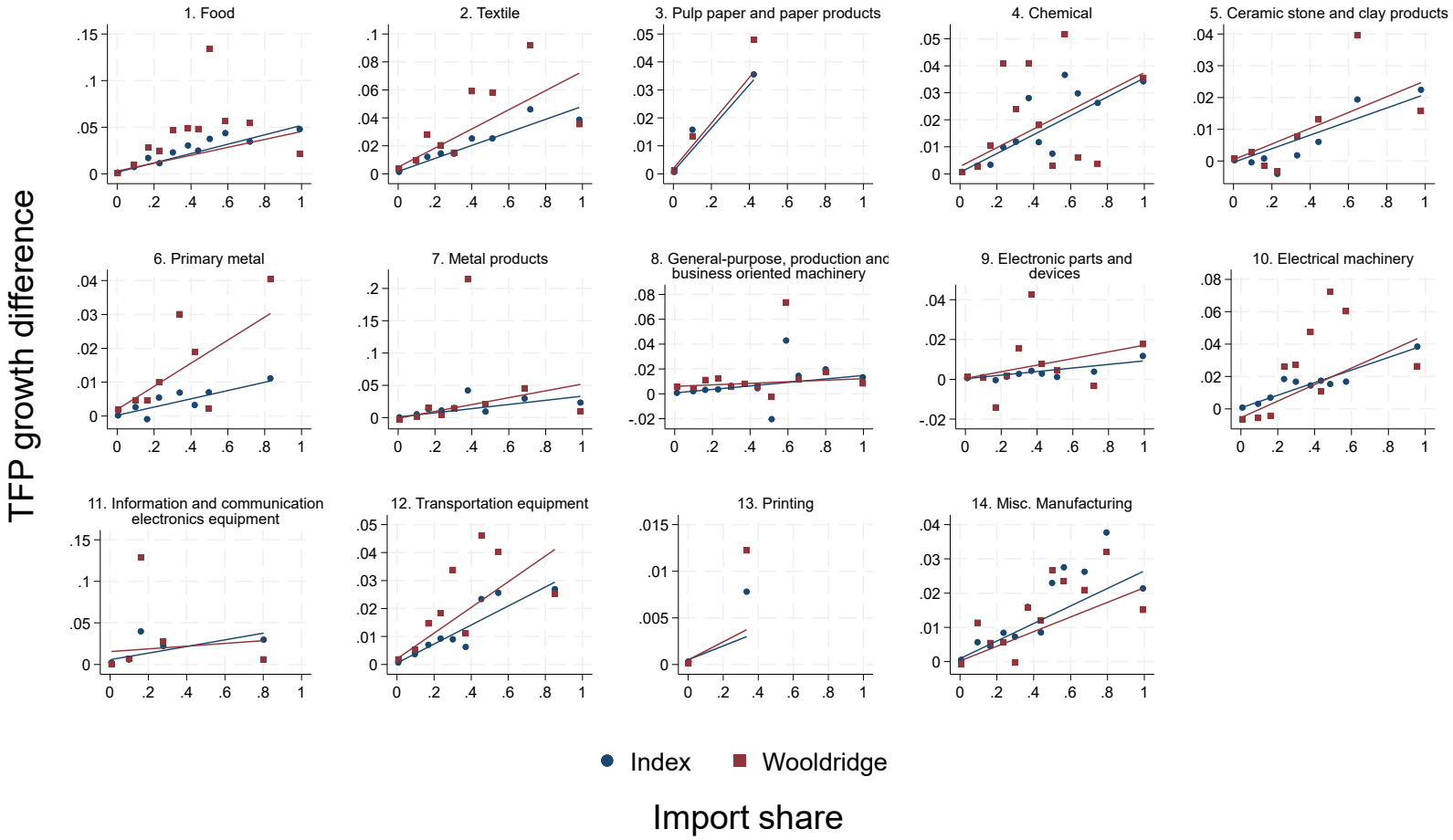
- Then, we calculate TFP growth rates between 2015 and 2020 separately for these 2 versions (namely, $\text{TFPgrowth}^{\text{JIP}}$ & $\text{TFPgrowth}^{\text{customs}}$)

- Finally, we obtain the outcome as follows:

$$\textbf{TFP growth difference} = \textbf{TFPgrowth}^{\textbf{JIP}} - \textbf{TFPgrowth}^{\textbf{customs}}$$

- This is our measure of the offshoring bias.

TFP growth difference vs. import share



- This figure uses SNA industry classifications.
- Each bin shows the average value of 10 or more firms.

Results (1) 2015-20 TFP growth difference
- TFP measured by Index method

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.0298 ***	0.0315 ***	0.0328 ***	0.0325 ***	0.0309 ***	0.0307 ***	0.0299 ***	0.0293 ***	0.0287 ***
	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0009)	(0.0009)	(0.0010)	(0.0010)	(0.0010)
Affiliate import share		- 0.0066	0.0033 *	0.0025	0.0027	0.0027	0.0028	0.0017	0.0014
		(0.0011)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
Import share × Affiliate import share			- 0.0180 ***	- 0.0172 ***	- 0.0185 ***	- 0.0185 ***	- 0.0184 ***	- 0.0173 ***	- 0.0171 ***
			(0.0027)	(0.0028)	(0.0028)	(0.0028)	(0.0028)	(0.0028)	(0.0028)
Chinese import share				0.0012 ***	0.0003	0.0003	0.0003	0.0001	0.0000
				(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Import share × Chinese import share					0.0061 ***	0.0063 ***	0.0072 ***	0.0080 ***	0.0084 ***
					(0.0017)	(0.0017)	(0.0018)	(0.0018)	(0.0018)
U.S. import share						0.0009	0.0003	- 0.0002	- 0.0003
						(0.0008)	(0.0009)	(0.0009)	(0.0009)
Import share × U.S. import share							0.0048 *	0.0054 *	0.0049 *
							(0.0028)	(0.0028)	(0.0028)
Employment								0.0007 ***	0.0006 ***
								(0.0002)	(0.0002)
R&D share									0.0151 ***
									(0.0059)
Observations	8,913	8,913	8,913	8,913	8,913	8,913	8,913	8,913	8,913
R-squared	0.2026	0.2055	0.2093	0.2100	0.2111	0.2112	0.2115	0.2131	0.2137

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All independent variables are 2015 values.

Results (2) 2015-20 TFP growth difference
- TFP measured by Wooldridge (2009)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.0294 ***	0.0289 ***	0.0305 ***	0.0299 ***	0.0307 ***	0.0306 ***	0.0328 ***	0.0326 ***	0.0364 ***
	(0.0020)	(0.0022)	(0.0023)	(0.0023)	(0.0028)	(0.0028)	(0.0032)	(0.0033)	(0.0033)
Affiliate import share		0.0018	0.0132 **	0.0113 *	0.0112 *	0.0112 *	0.0110 *	0.0106 *	0.0126 **
		(0.0037)	(0.0061)	(0.0062)	(0.0062)	(0.0062)	(0.0062)	(0.0062)	(0.0062)
Import share × Affiliate import share			- 0.0208 **	- 0.0190 **	- 0.0183 **	- 0.0183 **	- 0.0184 **	- 0.0179 **	- 0.0193 **
			(0.0088)	(0.0089)	(0.0089)	(0.0089)	(0.0089)	(0.0090)	(0.0090)
Chinese import share				0.0025 *	0.0029 *	0.0030 *	0.0030 *	0.0030 *	0.0032 **
				(0.0014)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Import share × Chinese import share					- 0.0031	- 0.0030	- 0.0052	- 0.0048	- 0.0078
					(0.0054)	(0.0054)	(0.0057)	(0.0057)	(0.0057)
U.S. import share						0.0005	0.0021	0.0019	0.0024
						(0.0025)	(0.0028)	(0.0028)	(0.0028)
Import share × U.S. import share							- 0.0122	- 0.0120	- 0.0088
							(0.0089)	(0.0089)	(0.0089)
Employment								0.0003	0.0010 *
								(0.0005)	(0.0005)
R&D share									- 0.1032 ***
									(0.0188)
Observations	8,913	8,913	8,913	8,913	8,913	8,913	8,913	8,913	8,913
R-squared	0.0237	0.0237	0.0243	0.0247	0.0247	0.0247	0.0249	0.0250	0.0282

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All independent variables are 2015 values.

Results

- The findings suggest that the offshoring bias is increasing in the import share.
  - If a firm imports more intermediate inputs, then it is more likely to overestimate its productivity with the standard estimation methods.
- However, the impact is decreasing in the affiliate import share.
  - When a firm imports more from its affiliate firms, it does not lead to the offshoring bias.
- Also, the results imply that the bias increases when a firm imports more from China although the magnitude is small.

Conclusion

- There has been discussion on the GVC and productivity.
- However, when a firm import cheap intermediate inputs, it leads to the overestimation of productivity using the standard methods.

- To our knowledge, this is the first study to quantify the offshoring bias using the granular customs data.
- We quantify the TFP growth gap with the customs data and show that the gap is widening with firm's import share.

Appendix

Descriptive statistics

variables	Obs.	mean	s.d.	p10	p50	p90
TFP growth difference : Index	8649	0.0034	0.0146	-0.0011	0.0002	0.0097
TFP growth difference : Wooldridge	8649	0.0053	0.0466	-0.0020	0.0001	0.0123
Import share	8649	0.0836	0.1996	0.0000	0.0003	0.2673
Affiliate import share	8649	0.0361	0.1358	0.0000	0.0000	0.0615
Chinese import share	8649	0.2089	0.3537	0.0000	0.0000	0.9577
U.S. import share	8649	0.0624	0.1939	0.0000	0.0000	0.1513
Employment	8649	458.9871	1868.7074	68.0000	153.0000	767.2308
R&D cost share	8649	0.0105	0.0261	0.0000	0.0002	0.0324

Note : Variables except TFP growth difference represent 2015 values.

Appendix : 2015-19 growth difference, Index

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.0264 ***	0.0274 ***	0.0284 ***	0.0283 ***	0.0268 ***	0.0266 ***	0.0259 ***	0.0255 ***	0.0252 ***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0008)	(0.0008)	(0.0009)	(0.0009)	(0.0009)
Affiliate import share		- 0.0038	0.0031 *	0.0027	0.0029 *	0.0029 *	0.0030 *	0.0023	0.0021
		(0.0010)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)
Import share × Affiliate import share			- 0.0127 ***	- 0.0123 ***	- 0.0134 ***	- 0.0133 ***	- 0.0133 ***	- 0.0126 ***	- 0.0124 ***
			(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0025)	(0.0025)
Chinese import share				0.0006	- 0.0002	- 0.0002	- 0.0002	- 0.0003	- 0.0004
				(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Import share × Chinese import share					0.0053 ***	0.0055 ***	0.0063 ***	0.0068 ***	0.0070 ***
					(0.0015)	(0.0015)	(0.0016)	(0.0016)	(0.0016)
U.S. import share						0.0011	0.0005	0.0002	0.0002
						(0.0007)	(0.0008)	(0.0008)	(0.0008)
Import share × U.S. import share							0.0041 *	0.0044 *	0.0042 *
							(0.0024)	(0.0024)	(0.0024)
Employment								0.0005 ***	0.0004 ***
								(0.0001)	(0.0001)
R&D share									0.0080
									(0.0052)
Observations	9,754	9,754	9,754	9,754	9,754	9,754	9,754	9,754	9,754
R-squared	0.1917	0.1929	0.1952	0.1953	0.1964	0.1966	0.1968	0.1978	0.1980

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All independent variables are 2015 values.

Appendix : 2015-19 growth difference, Wooldridge

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.0182 ***	0.0178 ***	0.0195 ***	0.0187 ***	0.0176 ***	0.0164 ***	0.0141 ***	0.0142 ***	0.0162 ***
	(0.0025)	(0.0028)	(0.0029)	(0.0030)	(0.0035)	(0.0036)	(0.0041)	(0.0042)	(0.0043)
Affiliate import share		0.0016	0.0140 *	0.0116	0.0117	0.0117	0.0119	0.0121	0.0133 *
		(0.0046)	(0.0077)	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0079)
Import share × Affiliate import share			- 0.0225 **	- 0.0202 *	- 0.0210 *	- 0.0206 *	- 0.0205 *	- 0.0207 *	- 0.0216 *
			(0.0111)	(0.0112)	(0.0113)	(0.0113)	(0.0113)	(0.0113)	(0.0113)
Chinese import share				0.0033 *	0.0027	0.0030	0.0029	0.0029	0.0031
				(0.0018)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
Import share × Chinese import share					0.0040	0.0054	0.0076	0.0075	0.0060
					(0.0068)	(0.0069)	(0.0072)	(0.0072)	(0.0072)
U.S. import share						0.0062 *	0.0046	0.0046	0.0049
						(0.0032)	(0.0035)	(0.0035)	(0.0035)
Import share × U.S. import share							0.0121	0.0120	0.0132
							(0.0112)	(0.0112)	(0.0112)
Employment								- 0.0001	0.0003
								(0.0006)	(0.0007)
R&D share									- 0.0527 **
									(0.0239)
Observations	9,754	9,754	9,754	9,754	9,754	9,754	9,754	9,754	9,754
R-squared	0.0053	0.0053	0.0057	0.0060	0.0061	0.0065	0.0066	0.0066	0.0071

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All independent variables are 2015 values.

Appendix : 2016-20 growth difference, Index

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.0149 ***	0.0165 ***	0.0167 ***	0.0167 ***	0.0186 ***	0.0187 ***	0.0188 ***	0.0184 ***	0.0183 ***
	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0008)	(0.0008)	(0.0009)	(0.0009)	(0.0009)
Affiliate import share		- 0.0062 ***	- 0.0049 ***	- 0.0048 ***	- 0.0050 ***	- 0.0050 ***	- 0.0050 ***	- 0.0058 ***	- 0.0059 ***
		(0.0010)	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Import share × Affiliate import share			- 0.0024	- 0.0024	- 0.0014	- 0.0014	- 0.0014	- 0.0007	- 0.0006
			(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)
Chinese import share				0.0000	0.0010 **	0.0010 **	0.0010 **	0.0008 *	0.0008 *
				(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Import share × Chinese import share					- 0.0070 ***	- 0.0071 ***	- 0.0072 ***	- 0.0066 ***	- 0.0065 ***
					(0.0015)	(0.0015)	(0.0015)	(0.0016)	(0.0016)
U.S. import share						- 0.0006	- 0.0005	- 0.0009	- 0.0009
						(0.0007)	(0.0008)	(0.0008)	(0.0008)
Import share × U.S. import share							- 0.0007	- 0.0004	- 0.0005
							(0.0025)	(0.0025)	(0.0025)
Employment								0.0005 ***	0.0005 ***
								(0.0001)	(0.0001)
R&D share									0.0053 **
									(0.0023)
Observations	9,840	9,840	9,840	9,840	9,840	9,840	9,840	9,840	9,840
R-squared	0.0687	0.0723	0.0724	0.0724	0.0745	0.0745	0.0746	0.0758	0.0763

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All independent variables are 2015 values.

Appendix : 2016-20 growth difference, Wooldridge

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import share	0.0154 ***	0.0146 ***	0.0118 ***	0.0119 ***	0.0169 ***	0.0176 ***	0.0214 ***	0.0215 ***	0.0216 ***
	(0.0020)	(0.0022)	(0.0023)	(0.0023)	(0.0027)	(0.0027)	(0.0031)	(0.0031)	(0.0031)
Affiliate import share		0.0032	- 0.0182 ***	- 0.0180 ***	- 0.0184 ***	- 0.0184 ***	- 0.0186 ***	- 0.0185 ***	- 0.0184 ***
		(0.0036)	(0.0062)	(0.0063)	(0.0063)	(0.0063)	(0.0063)	(0.0063)	(0.0063)
Import share × Affiliate import share			0.0373 ***	0.0370 ***	0.0398 ***	0.0394 ***	0.0388 ***	0.0388 ***	0.0387 ***
			(0.0088)	(0.0088)	(0.0089)	(0.0089)	(0.0089)	(0.0089)	(0.0089)
Chinese import share				- 0.0004	0.0023	0.0021	0.0023	0.0023	0.0023
				(0.0014)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Import share × Chinese import share					- 0.0185 ***	- 0.0194 ***	- 0.0231 ***	- 0.0231 ***	- 0.0232 ***
					(0.0052)	(0.0053)	(0.0055)	(0.0055)	(0.0055)
U.S. import share						- 0.0044 *	- 0.0013	- 0.0013	- 0.0013
						(0.0026)	(0.0028)	(0.0029)	(0.0029)
Import share × U.S. import share							- 0.0225 **	- 0.0225 **	- 0.0224 **
							(0.0088)	(0.0088)	(0.0088)
Employment								- 0.0001	0.0000
								(0.0005)	(0.0005)
R&D share									- 0.0048
									(0.0082)
Observations	9,840	9,840	9,840	9,840	9,840	9,840	9,840	9,840	9,840
R-squared	0.0063	0.0064	0.0082	0.0082	0.0095	0.0098	0.0104	0.0104	0.0105

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All independent variables are 2015 values.

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