

Processing Trade, Productivity and Prices: Evidence from a Chinese Production Survey

Yao Amber Li¹ Valerie Smeets² Frederic Warzynski²

¹Hong Kong University of Science and Technology

²Aarhus University

International Workshop on “Frontiers in Research on Offshoring”
Research Institute of Economy, Trade and Industry (RIETI)
Hitotsubashi Institute for Advanced Study
August 2, 2019

Motivation

- Changing nature of manufacturing and international trade has led to an increased fragmentation of the supply chain
- A particular form of fragmented production is processing trade
 - Since 2000, at least 18% of exports from developing countries come from processing trade
 - By 2006, 130 countries had established 3500 export processing zones
 - China: approximately 50% of exports are processing trade
- However little is known about the link between firms' performance and the fragmentation of production
 - Hard to answer because of new measurement issues introduced by the fragmentation of production

Motivation (cont.)

- Well documented exporter premium in most countries since mid-90's
- Is China exceptional?
- China is also the largest exporter in the world
- Our question: Are we properly measuring productivity? Any mismeasurement?
- Investigate in particular the role of pricing heterogeneity in relation with one important characteristic of Chinese manufacturing: processing trade

This paper

- We investigate whether firm's performance (productivity) is affected by participating in a fragmented production network
 - We study the role of processing trade and its pricing implications on firm-level productivity using a unique combination of datasets from China
 - We provide evidence of a large bias toward firms engaged into processing trade, mostly explained by prices differences
- We show that
 - Exporters have higher physical productivity but not necessarily higher revenue productivity
 - Exporters charge lower prices
 - Those effects are mostly driven by processing trade
- This suggests that it is important to take into account the type of trade transactions firms have with their foreign buyers

China development policy and institutions

- Offshoring to China encouraged through processing trade
 - Specific type of institution where goods are assembled from inputs which are exempted from tariffs (FTZs)
- Different modes of processing trade
 - Processing with assembly
 - Processing using imported inputs
- Different types of firms cohabit in the same product market
 - Ordinary trade
 - Processing trade
 - Combination of both (hybrid)
- Those types of firms may exhibit very different level of efficiency as well as different pricing scheme

Empirical strategy

- Employ a unique firm-product production quantity database to estimate TFPQ for Chinese firms engaged in various mode of exports and compare TFPQ with TFPR
- Address potential biases in TFP estimations
- Relate differences between TFPR and TFPQ to output pricing differences

Related literature

- A few papers have investigated the link between revenue productivity and exporting for Chinese firms
 - Lu (2010) documents a negative premium for Chinese exporters
 - Dai et al. (2016) associate the negative export premium to the role of processing trade
- Previous papers focus only on TFPR
 - We compare TFPR and TFPQ for exporters and firms involved in processing trade
 - We show that the previous result reverses while taking into account prices differences
- Linked to a larger literature in productivity measurement (e.g. Foster Haltiwanger and Syverson, 2008; De Loecker, 2011)
- Closely related to recent papers looking at physical rather than revenue productivity (Smeets and Warzynski, 2013; Garcia-Marin and Voigtlander, 2013)

Productivity estimation and pricing heterogeneity

- To estimate productivity, most researchers use revenues as a proxy for the output firms produce
- While revenues is a function of output, it also depends on output price ($R_{it} = P_{it}Q_{it}$)
- If firms price differently, estimating TFP using revenues (TFPR) will lead to an “output price bias”
 - TFPR will be a combination of technical efficiency and demand
- Solution proposed in the literature is to use quantity for output instead of revenues (TFPQ)
 - Easy to implement for single product firms (e.g. Foster et al. (2008))
 - More complicated for multi product firms (e.g. De Loecker et al. (for short DLGKP 2016), Dhyne et al. (2017))

Productivity estimation and pricing heterogeneity (cont.)

- A similar story holds for inputs, especially materials
 - If firms buy materials at different prices, their measured productivity will also reflect those input prices differences
- Solution proposed in the literature is to find a proxy for input prices
 - Augment the usual productivity estimation by adding a function of output prices and market share in the control function (de Loecker et al. (2016))
- The price bias on both the output and input side has been shown to seriously affect estimates of productivity
- The problem may be even more severe for firms involved in different modes of trade, especially processing trade
 - Systematic differences between modes of export, technical efficiency and pricing
 - E.g. selection into processing, product market competition, provision/purchase of inputs under certain conditions, network externalities

Data

- Balance Sheets (Manufacturing Survey): widely used
 - NBSC, 2000-2006
 - Sales, materials, capital, labor, ownership, location
- Trade Data: widely used
 - Chinese Customs, 2000-2006
 - Firm-product transactions data at HS8
 - Transaction mode: processing trade, only ordinary trade or a mix of the two (hybrid trade)
 - Merge with other datasets based on firm name and other information
- Firm-Product Production Data: less used
 - NBSC, 2000-2006
 - Quantity produced
 - Firm-product survey for more than 800 most important products
 - Approximately 186,000 manufacturing firms
 - Match on firm ID with balance sheets

Firm-Product Production Data

- Product code quite aggregated:
“main industrial products” as defined by the Chinese government at the country level
- Data organized in an hierarchical way
- Consider more specifically a series of products that can be matched relatively easily to customs data using HS code.
Example: Leather shoes (product code 5901) span over several HS4 categories: 6401 to 6405

HS product code in customs data:

- 64 FOOTWEAR; GAITERS AND THE LIKE; PARTS OF SUCH ARTICLES**
- 6401** Footwear; waterproof, with outer soles and uppers of rubber or plastics, (uppers not fixed to the sole nor assembled by stitch, rivet, nail, screw, plug or similar)
- 6402** Footwear; with outer soles and uppers of rubber or plastics (excluding waterproof footwear)
- 6403** Footwear; with outer soles of rubber, plastics, leather or composition leather and uppers of leather
- 6404** Footwear; with outer soles of rubber, plastics, leather or composition leather and uppers of textile materials
- 6405** Footwear; other footwear n.e.c. in chapter 64
- 6406** Footwear; parts of footwear; removable in-soles, heel cushions and similar articles; gaiters, le.g.ings and similar articles, and parts thereof

Product code in NBSC firm-product production data:

5449	服装	万件	1810	Clothing
5456				
5457	梭织服装	万件	1810	Woven garments
5550	西服及西服套装	万件	1810	suits
5609	衬衫	万件	1810	Shirt
5623	儿童服装	万件	1810	kids clothing
5654	针织服装	万件	1810	Knitwear
5765	羽绒服	万件	1810	winter jacket
5772				Hat
5883	轻革	平方米	1910	Light leather
5901	皮鞋	万双	1921	Leather shoes
6024	皮革服装	件	1922	Leather Clothing
6049	天然皮革手提包(袋)、背包	万个	1923	Natural leather handbags (bags), backpacks
6128	毛皮服装	件	1932	Fur
6253	人造板	立方米	2020	Wood-based panels
6260	胶合板	立方米	2020	
6284	纤维板	立方米	2020	
6333	刨花板	立方米	2020	
6413	人造板表面装饰板(人造板二次加工装饰板)	平方米	2029	
6420	实木地板(木地板)	平方米	2031	
6421	复合地板	平方米	2031	

2982	饮料酒	千升	152	Alcoholic beverages
2999	白酒（折65度，商品量）	千升	1521	white liquor
3012	啤酒	千升	1522	beer
3036	葡萄酒	千升	1524	wine
3067	软饮料	吨	1530	soft drink
3074	碳酸饮料	吨	1531	soda

24306	钢材	吨	3230	Steel
24597	铁道用钢材	吨	3230	
24608	重轨	吨	3230	
24622	轻轨	吨	3230	
24684	大型型钢	吨	3230	
24726	中小型型钢	吨	3230	
24727	棒材	吨	3230	
24728	钢筋	吨	3230	
25127	盘条(线材)	吨	3230	
25172	特厚板	吨	3230	
25173	厚钢板	吨	3230	
25174	中板	吨	3230	
25387	热轧薄板	吨	3230	
25405	冷轧薄板	吨	3230	
25406	中厚宽钢带	吨	3230	
25407	热轧薄宽钢带	吨	3230	
25408	热轧窄钢带	吨	3230	
25409	冷轧窄钢带	吨	3230	
25410	镀层板(带)	吨	3230	
25436	镀锌板(带)	吨	3230	
25467	镀锡板(带)	吨	3230	
25500	涂层板(带)	吨	3230	
25501	电工钢板(带)	吨	3230	
25511	冷轧薄宽钢带	吨	3230	
25696	无缝钢管	吨	3230	
25863	焊接钢管	吨	3230	
26003	其它钢材	吨	3230	

Sampling strategy

- Our strategy is to identify products
 - Reported consistently over the years
 - Where most firms are single-product
 - With very little carry along trade (focused on production)
 - Dominated by Chinese firms
 - Export oriented
 - Where processing trade widely used
- Currently focus on leather shoes (and shirts)
- Later compare with other types of products more focused on the domestic market (beer and rice)

Getting a proxy for price

- We know physical quantity by product but not revenue (from production survey)
- For single product firms, we know firm revenue (from balance sheets)
- Dividing revenue by quantity is a good proxy for price if little revenue comes from other sources
- Good assumption for leather shoes:
 - More than 75% of firms only export shoes and 95% of firms only export shoes and part of shoes
 - 90% firms are single product firms for leather shoes

Sample: Leather Shoes Producer

- Matching rate between NBSC data and Customs data: 83%

Table 1: Summary statistics on export behavior (leather shoes producers)

	share exporters	share matched exporters	among matched exporters: mode of export		
			share processing	share hybrid	share ordinary
2000	65.55%	57.69%	25.78%	15.11%	59.11%
2001	62.67%	55.69%	26.28%	20.44%	53.28%
2002	65.74%	53.59%	26.52%	29.57%	43.90%
2003	62.56%	55.52%	25.94%	37.46%	36.60%
2004	71.07%	51.81%	21.68%	44.52%	33.80%
2005	62.82%	56.59%	23.47%	43.13%	33.40%
2006	56.96%	59.58%	22.20%	42.81%	34.99%

The matched exporters are dominated by foreign invested firms:
 HKMTW 46.86%; OECD 36.86%

Sample: Leather Shoes Producer

Year	# Firms	Non exporters	Exporters	Match btw NBSC and customs
2000	595	205	390	77.3%
2001	785	293	492	75.2%
2002	931	319	612	83.3%
2003	999	374	625	83.3%
2004	1,165	337	828	81.8%
2005	1,474	548	926	88.0%
2006	1,659	714	945	87.0%
All	7,608	2,790	4,818	83.0%

Sample: Leather Shoes Producer

Year	Share of firms in			Share of trade value in		
	Processing trade	Ordinary trade	Hybrid trade	Processing trade	Ordinary trade	Hybrid trade
2000	25.8%	15.1%	59.1%	20.2%	2.5%	73.4%
2001	26.3%	20.4%	53.3%	24.8%	4.9%	69.2%
2002	26.5%	29.6%	43.9%	33.2%	11.8%	54.1%
2003	25.9%	37.5%	36.6%	33.7%	14.4%	51.4%
2004	21.7%	44.5%	33.8%	27.2%	14.7%	56.9%
2005	23.5%	43.1%	33.4%	31.5%	15.9%	52.3%
2006	22.2%	42.8%	35.0%	32.2%	16.4%	51.3%

Summary of Results

- show production function estimation with deflated revenue and physical quantity (various methods)
- look at export premium for both TFPR and TFPQ
- look at the link between TFPs and the mode of trade
- Robustness and additional facts

Results: Leather Shoes Producer

Panel A: production function estimation

	Using deflated revenue, dep. var.: $\log DefRev$		Using physical quantity, dep. var.: $\log Q$	
	OLS - Cobb Douglas (coeff)	DLGKP - translog (median elasticity)	OLS - Cobb Douglas (coeff)	DLGKP - translog (median elasticity)
$\log M$	0.820*** (0.004)	0.855	0.639*** (0.012)	0.856
$\log L$	0.151*** (0.004)	0.115	0.178*** (0.011)	0.109
$\log K$	0.025*** (0.003)	0.010	0.003 (0.007)	0.012
# obs.	6,333	3,754	6,333	3,754

Panel B: link between productivity estimates and export

	Dep. var.: $TFPR$		Dep. var.: $TFPQ$	
	OLS - Cobb Douglas	DLGKP - translog	OLS - Cobb Douglas	DLGKP - translog
EXP	-0.033*** (0.012)	-0.020*** (0.007)	0.133*** (0.017)	0.209*** (0.028)

The Link between TFPR, TFPQ and Exporting

Specification:	Leather shoes producer: DLGKP				
	TFPR		TFPQ		Price
Exporter	-0.020*** (0.007)	0.001 (0.008)	0.209*** (0.028)	0.087*** (0.023)	-0.085*** (0.023)
Year fixed effects	yes	yes	yes	yes	yes
Firm size control	yes	yes	yes	yes	yes
Location and ownership control		yes		yes	yes
No. of observations	3,754	3,731	3,754	3,731	3,731

The Link between TFPR, TFPQ and Exporting

- Without controls
 - TFPR lower for exporters (as found in other studies) but TFPQ higher
- Controlling for ownership and location
 - Exporters are no different than domestic firms in TFPR but exhibit premium in TFPQ
 - Price differences of 9%
- Important to control for location and ownership
- $\text{corr}(TFPR_{it}, p_{it}) > 0$ but $\text{corr}(TFPQ_{it}, p_{it}) < 0$

The Link between TFPR, TFPQ and Modes of Exports

Specification:	Leather shoes producer: DLGKP				
	TFPR		TFPQ		Price
Ordinary trade	-0.030*** (0.009)	-0.012 (0.010)	0.236*** (0.039)	-0.014 (0.033)	0.001 (0.033)
Processing trade	-0.037*** (0.013)	0.050*** (0.018)	0.333*** (0.053)	0.148*** (0.057)	-0.099* (0.058)
Hybrid trade	0.021* (0.011)	0.038*** (0.014)	0.051 (0.045)	0.043 (0.043)	-0.006 (0.044)
Year fixed effects	yes	yes	yes	yes	yes
Firm size control	yes	yes	yes	yes	yes
Location and ownership control		yes		yes	yes
No. of observations	2,558	2,548	2,558	2,548	2,548

Note: default category is non exporter.

The Link between TFPR, TFPQ and Modes of Exports

- Systematic differences between the effect of mode of trade on TFPR vs. TFPQ
 - TFPR underestimates the effect of various modes of trade
 - Bias is especially serious for processing trade
- Using TFPR, processing trade is associated with 5% productivity gains, while using TFPQ, it is associated with 15% productivity gains
- Pricing differences explain the discrepancy between those two effects
- While processing trade is marginally more efficient than hybrid trade when using TFPR, differences are large when using TFPQ

Other facts and robustness

- Split processing trade in pure assembly vs. processing with imported input
 - Results driven by pure assembly
 - In production function estimation, parameter of materials is much lower for pure assembly firms
- Export prices correlate highly with our price proxy
 - Processing trade is associated with lower export prices
- Processing trade firms are more likely to be owned by foreigners (FDI more likely than JVs or domestically private)
- Controlling for special economic zones (SEZs) or state subsidies does not affect the results

Two Types of Processing Trade

Dep. var. :	TFPQ	logp	TFPR
Processing with imp. inputs	-0.050 (0.053)	0.098* (0.054)	0.053*** (0.018)
Pure assembly	0.652*** (0.073)	-0.628*** (0.074)	0.016 (0.024)
Ordinary	-0.028 (0.032)	0.016 (0.032)	-0.011 (0.011)
hybrid	0.011 (0.051)	0.047 (0.051)	0.058*** (0.017)
ju	0.001 (0.037)	-0.009 (0.037)	-0.010 (0.012)
other	-0.040 (0.033)	0.035 (0.033)	-0.005 (0.011)
OECD	0.056 (0.052)	-0.058 (0.052)	-0.002 (0.017)
HKMTW	0.220*** (0.047)	-0.248*** (0.047)	-0.031** (0.016)
r^2	0.602	0.613	0.214
No. of observations	2,559	2,559	2,559

Robustness: shirts

Panel A: production function estimation

	Using deflated revenue, dep. var.: $\log DefRev$		Using physical quantity, dep. var.: $\log Q$	
	OLS - Cobb Douglas (coeff)	DLGKP - translog (median elasticity)	OLS - Cobb Douglas (coeff)	DLGKP - translog (median elasticity)
$\log M$	0.818*** (0.005)	0.770	0.440*** (0.020)	0.769
$\log L$	0.139*** (0.007)	0.128	0.453*** (0.026)	0.126
$\log K$	0.035*** (0.004)	0.021	-0.116*** (0.015)	0.022
# obs.	3,349	2,035	3,349	2,035

Panel B: link between productivity estimates and export

	Dep. var.: $TFPR$		Dep. var.: $TFPQ$	
	OLS - Cobb Douglas	DLGKP - translog	OLS - Cobb Douglas	DLGKP - translog
EXP	0.005 (0.008)	-0.006 (0.011)	0.210*** (0.033)	0.236*** (0.043)

Conclusion

- Firms' performance is affected by participating in a fragmented production network
 - Large bias toward firms engaged into processing trade
 - In the Chinese footwear industry, exporters are not less efficient; they price differently, which is reflected by large differences between TFPR and TFPQ
- It is important to take into account the type of trade relationships firms have with their foreign buyers
 - Productivity measurement
 - Policy questions related to the impact of trade liberalization and the emergence of processing trade on firms' efficiency
- Various channels
 - Trade liberalization
 - Type of processing trade
 - Transfer pricing

Further Discussion: Why Processing Trade Firms Charge Lower Prices

- Processing trade: freely provided inputs, tariff exemption effect
 - We added artificially the average tariff for processing trade firms and “inflate” their material input cost
 - Results do not alter much → mostly other reasons explain current results
- Transfer pricing: preferential pricing of materials, buyers externalities

Next Steps

- Type of processing trade: VAT exemption effect
- Generalize to other products (e.g., suits)
- Seriously model fragmented production network in the production function

Future Research Agenda: Technology and Firm Reorganization

- Big picture 1: Has the labor demand changed over time?
 - Firm perspective
 - Occupations and tasks
 - Dying vs. surviving vs. new occupations/tasks
 - Mapping of occupations/tasks with skills
 - skills as very detailed education profiles
- Big picture 2: Has the labor supply changed over time?
 - Worker perspective
 - Skills
 - Match/mismatch of supply and demand

Future Research Agenda: Technology and Firm Reorganization

- Identification
 - Use technological change as the shock driving reorganization (affecting labor demand)
 - Proxy with IT or RD surveys, investments
 - Identification of causality via IV strategy
- Policy implication 1
 - Future jobs needed by firms
 - Which skills will map those jobs
 - Education recommendations
- Policy implication 2
 - How technology affects jobs
 - Destruction vs. creation (losers and winners)
 - Skills upgrading to ease the transition
 - Retraining or change in skills developed in educational programs

Q & A

Thank you!

Table 2: Production function estimation: leather shoes

Dep. var.: logQ	OLS (coeff)	correcting for price WOP (coeff)	correcting for price WLP (coeff)	DLGKP - translog (median elasticity)
logM	0.639*** (0.012)	0.857*** (0.018)	0.840*** (0.211)	0.856
logL	0.178*** (0.011)	0.129*** (0.015)	0.138*** (0.037)	0.109
logK	0.003 (0.007)	0.013* (0.006)	0.016 (0.022)	0.012
# obs.	6,333	1,675	2,181	3,754
Dep. var.: TFPQ				
EXP	0.133*** (0.017)	0.217*** (0.043)	0.214*** (0.038)	0.209*** (0.028)
logL	-0.020*** (0.007)	-0.130*** (0.016)	-0.103*** (0.015)	-0.106*** (0.011)
Dep. var.: logDefRev	OLS (coeff)	correcting for price WOP (coeff)	correcting for price WLP (coeff)	DLGKP - translog (median elasticity)
logM	0.820*** (0.004)	0.858*** (0.018)	0.849*** (0.213)	0.855
logL	0.151*** (0.004)	0.129*** (0.015)	0.137*** (0.037)	0.115
logK	0.025*** (0.003)	0.013** (0.006)	0.015 (0.022)	0.010
# obs.	6,333	1,675	2,181	3,754
Dep. var.: TFPR				
EXP	-0.034*** (0.007)	-0.033*** (0.012)	-0.040*** (0.012)	-0.020*** (0.007)
logL	0.005* (0.003)	0.015*** (0.004)	0.034*** (0.005)	0.022*** (0.003)

Table 3: Link between TFP and mode of export: leather shoes

	OLS	WOP correcting for price	WLP correcting for price	DLGKP
Dep. var.: TFPQ				
Ordinary	0.277*** (0.027)	0.199*** (0.054)	0.208*** (0.048)	0.236*** (0.039)
Processing	0.110*** (0.035)	0.395*** (0.078)	0.392*** (0.068)	0.333*** (0.053)
Hybrid	-0.029 (0.031)	0.137** (0.062)	0.138** (0.057)	0.051 (0.045)
logL	-0.020*** (0.007)	-0.130*** (0.016)	-0.103*** (0.015)	-0.106*** (0.011)
Dep. var.: TFPR				
Ordinary	-0.055*** (0.009)	-0.055*** (0.012)	-0.055*** (0.014)	-0.030*** (0.009)
Processing	-0.036*** (0.012)	-0.044*** (0.017)	-0.042** (0.020)	-0.037*** (0.013)
Hybrid	0.019* (0.011)	0.008 (0.014)	0.013 (0.017)	0.021* (0.011)
logL	0.005* (0.003)	0.015*** (0.004)	0.034*** (0.005)	0.022*** (0.003)

Note: default category, non exporters; the specification controls for year dummies and log of firm size

Table 4: Export price, mode of transaction and production price (matched exporters only)

Dep. var.: $\log p_{exp}$	(1)	(2)	(3)
processing	-0.094*** (0.018)	-	-0.026* (0.015)
$\log p$	-	0.416*** (0.008)	0.414*** (0.008)
cons	1.376*** (0.033)	-1.181*** (0.057)	-1.153*** (0.059)
HS6 dummies		YES	
Year dummies		YES	
r ²	0.243	0.460	0.461
N		5,992	

Table 5: Distribution of ownership type by mode of export (matched exporters only)

	# firms (%)	share processing
dom priv	412 (18.25%)	1.46%
other	299 (13.24%)	6.69%
ju	780 (34.54%)	20.26%
OECD	274 (12.13%)	36.86%
HKMTW	493 (21.83%)	46.86%

Table 6: Link between TFP and export behavior (with controls for ownership and location)

Dep. var. :	TFPQ	logp	TFPR
exp	0.087*** (0.023)	-0.085*** (0.023)	0.001 (0.008)
jv	-0.069* (0.031)	0.084** (0.031)	0.015 (0.010)
other	-0.040 (0.027)	0.050 (0.027)	0.010 (0.009)
OECD	-0.100* (0.044)	0.104* (0.044)	0.006 (0.015)
HKMTW	0.109** (0.038)	-0.116** (0.039)	-0.009 (0.013)
<i>logL</i>	-0.106*** (0.010)	0.123*** (0.011)	0.018*** (0.004)
cons	10.673*** (0.061)	-4.063*** (0.061)	13.521*** (0.021)
location dummies		YES	
year dummies		YES	
r2	0.542	0.556	0.200
N	3,731	3,731	3,731

Table 7: Link between TFP and mode of transaction (with controls for ownership and location)

Dep. var. :	TFPQ	logp	TFPR
Processing	0.148*** (0.057)	-0.099* (0.058)	0.050*** (0.018)
Ordinary	-0.014 (0.033)	0.001 (0.033)	-0.012 (0.010)
Hybrid	0.043 (0.043)	-0.006 (0.044)	0.038*** (0.014)
ju	-0.003 (0.037)	-0.006 (0.038)	-0.011 (0.012)
other	-0.037 (0.033)	0.033 (0.033)	-0.004 (0.010)
OECD	0.037 (0.053)	-0.037 (0.053)	0.000 (0.017)
HKMTW	0.205*** (0.048)	-0.233*** (0.048)	-0.030** (0.015)
<i>logL</i>	-0.104*** (0.013)	0.120*** (0.013)	0.018*** (0.004)
cons	10.623*** (0.072)	-4.000*** (0.073)	13.534*** (0.023)
location dummies	YES		
year dummies	YES		
r2	0.587	0.597	0.226
N	2,548	2,548	2,548