

# Input Prices, Productivity, and Trade Dynamics: Long-Run Effect of Liberalization on Chinese Paint Manufacturers

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# Input Tariff Liberalization and Productivity

- ▶ Substantial evidence that liberalization leads to productivity gains:
  - ▶ Goldberg, Khandelwal, Pavcnik and Topalova (2010),
  - ▶ Khandelwal and Topalova (2011),
  - ▶ De Loecker, Goldberg, Khandelwal and Pavnick (2016),
  - ▶ Brandt, van Biesenbroeck, Wang and Zhang (2015) .
- ▶ But this could be due to:
  - ▶ Direct importing.
  - ▶ Greater variety in domestic input market through middlemen importing.
  - ▶ Import competition in upstream market.

## Evidence Direct Importing improves Productivity

- ▶ Several papers find significant “learning by importing”:
  - ▶ Kasahara and Rodrigue (2008),
  - ▶ Kasahara and Lapham (2013),
  - ▶ Zhang (2017).
- ▶ These do not focus on liberalization events and do not explicitly control for tariff or input price changes.
  - ▶ So cheaper or better imported inputs are measured as productivity.

## Liberalization Effects via Direct Importing

- ▶ Do importers enjoy better materials access than non-importers?
- ▶ Does input tariff liberalization expand this advantage?
- ▶ Does importing raise productivity, beyond the impact on input prices?
- ▶ What is the overall effect of input tariff liberalization in the long run?
  - ▶ Does liberalization lead to increased import activity?
  - ▶ How does this affect aggregate productivity distribution?
  - ▶ How much of this effect is due to endogenous reaction of firms?

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## Measuring Direct Importing's effect on Productivity

- ▶ Firms **select** into importing.
- ▶ Importing leads to changes in **input price**
- ▶ ...which may alter firms' choice of **input quality**.
- ▶ **Data:** Materials prices and quality not directly observed.
- ▶ Dynamic effects occur over many years due to **sunk costs** of trade.
- ▶ Importing and **exporting** are correlated and potentially complementary.



# Our Approach

1. Consider paint manufacturing, product where imported inputs are important quality component.
2. Estimate production function and recover productivity and input prices.
3. Accounting for quality choice, and heterogeneous firms, estimate the effect of trade on productivity and input prices.
4. Estimate sunk and fixed cost of trade participation.
5. Counterfactual analysis to investigate import liberalization's effect on:
  - ▶ Input prices,
  - ▶ Trade participation,
  - ▶ Productivity,
  - ▶ Firm valuation.

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# What's New in This Paper

- ▶ **Multi-dimensional firm heterogeneity:** separate productivity from input prices.
- ▶ **Direct importing at the firm level:**
  - ▶ Heterogeneous input prices that depend on import status.
  - ▶ Importing boosts productivity (controlling for selection).
- ▶ **Dynamic effect:**
  - ▶ Interactions of input prices, productivity, and trade;
  - ▶ Counterfactual shows how import liberalization leads to
    - ▶ Mild short-run effect;
    - ▶ Large long-run effect: amplified through firms' endogenous trade response.

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# Preview of Empirical Results

1. Importing both lowers input prices and raises productivity.
  - ▶ Direct importers face roughly 2 percent lower quality-adjusted input prices.
  - ▶ Importing raises productivity 3 times as much as exporting.

## Preview of Empirical Results

1. Importing both lowers input prices and raises productivity.
2. WTO Tariff cuts increase incentive to import, but firms respond slowly.
  - ▶ Importing “discount” increases from 1.8 to 2.4 percent.
  - ▶ After 15 years, import participation increases from 12 to 15 percent.

## Preview of Empirical Results

1. Importing both lowers input prices and raises productivity.
2. WTO tariff cuts increase incentive to import, but firms respond slowly.
3. Slight increase in import incentive has long run effects on productivity:
  - ▶ Aggregate productivity increases 8.6 percent after 15 years.
  - ▶ Strengthens correlation between productivity and output, since tariff cut reduces input prices of trading firms.
  - ▶ Over half of productivity gains due to endogenous response of firms.

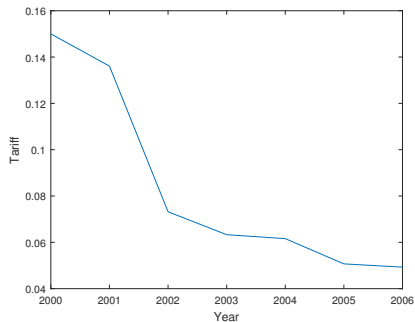
## Data: Chinese Paint Industry

Firm level data of Chinese paint manufacturers (2000-2006):

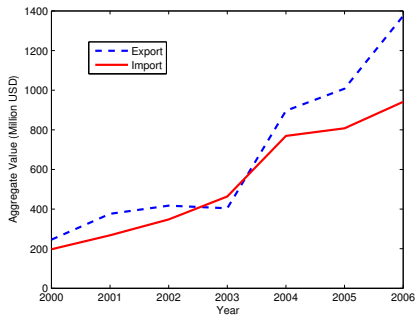
- ▶ Firm-level survey from National Bureau of Statistics in China
  - ▶ total sales, export sales, number of workers, wage expenditure, material expenditure, capital stock, etc.
- ▶ Custom records of import and export from Chinese customs
  - ▶ Trade participation indicators.

China joins WTO in Nov 2001, we assume the change was anticipated in 2000 assumed to be permanent.

# Chinese Paint: Tariffs, and Trade



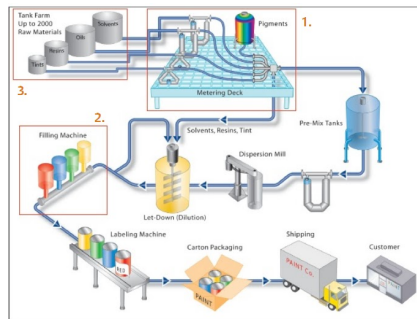
**Figure:** Tariff on Paint Inputs



**Figure:** Paint Mfgs Imports and Exports

▶ Trade Partners

# Manufacturing Process At-A-Glance



- ▶ Paint quality is largely determined by quality of inputs.
  - ▶ High-quality resin → high-quality of paint;
  - ▶ Heavy Metals (lead) → non-environmental-friendly paint;
  - ▶ Volatile Organic Compounds (VOCs) → toxic paint;
- ▶ Labor is used for measurement of ingredients, preventing waste of inputs.

# Imported Inputs available Domestically

**1688** 进口涂料原料  
www.1688.com

产品 公司



共 1766 条 进口涂料原料 信息



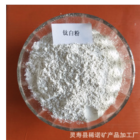
**钛白粉R930**  
产地：泰国  
**¥26.00** 成交2笔  
优势供应进口钛白粉R930 钛白粉 粉底原料 钛白粉涂料原料  
广州佳琪生物科技... 2年  
广州市白云区



**¥32.00** 成交2笔  
厂家直销进口羟乙基纤维素HEC3W/5W粘度。各种涂料原料及配套助剂  
郑州新蓝化工产品... 2年  
郑州市



**钛白粉R930**  
订购热线 13660573261  
**¥26.00** 成交7笔  
优势供应进口钛白粉R930 钛白粉 粉底原料 钛白粉涂料原料  
广州红晶生物科技... 6年  
广州市白云区



**¥15.00** 成交0笔  
优势供应进口钛白粉R930 钛白粉 粉底原料 钛白粉涂料原料  
灵寿县稀诺矿产品... 1年  
灵寿县



**¥25.00** 成交1笔  
优势供应进口钛白粉R930 钛白粉 粉底原料 钛白粉涂料原料  
广州强发生物科技... 2年  
广州市白云区



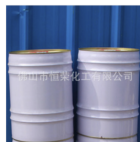
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优势供应进口钛白粉R930 钛白粉 粉底原料 钛白粉涂料原料  
石家庄专业化工有... 4年  
高邑县



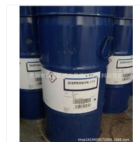
**¥21000...** 成交0笔  
优势供应进口钛白粉R930 钛白粉 粉底原料 涂料原料 (日本石原)  
石家庄专业化工有... 4年  
石家庄市长安区



**钛白粉 R-930**  
订购热线 18675885782  
**¥26.00** 成交0笔  
优势供应进口钛白粉R930 钛白粉 粉底原料 钛白粉涂料原料 (日本石原)  
深圳市辉乐达科技... 3年  
深圳市



**¥16.80** 成交0笔  
生产优质黄面固化剂 深圳PU木器底漆配套作用进口原料高固含量  
佛山市恒荣新材料... 5年  
佛山市顺德区



**¥192.00** 成交0笔  
批发分散剂 德国毕克 BYK-111无机颜料分散剂 涂料分散剂  
深圳市宝安区西乡... 4年  
东莞市

# Imported Inputs available Domestically



¥ 26.00 Turnover 1 pens

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Guangzhou Jia Qi ... 2 years

Guangzhou B...



¥ 32.00 Traded 2 pens

Factory direct imports of hydroxyethyl cellulose HEC3W / SW viscosity, a

Zhengzhou New K... 2 years

Zhengzhou City



\$ 26.00 Traded 7 pencils

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Guangzhou Hongc... 6 years

Guangzhou B...



\$ 15.00 Traded 0 pen

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Ling Shouyan dilu... 1 year

Lingshou Cou...



\$ 25.00 Turnover 1 pens

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Guangzhou strong... 2 years

Guangzhou B...



\$ 17.60 Traded 0 pen

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Shijiazhuang Taim... 4 years

Gaoyi County



¥ 2100... Sold 0 pen

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Shijiazhuang Zhuo... 4 years

Shijiazhuang ...

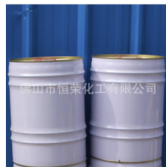


\$ 26.00 Traded 0 pen

Advantages Supply of imported titanium dioxide R930 titanium dioxide

Shenzhen Fuda Te... 3 years

Shenzhen



¥ 16.80 Transactions 0 pen

Production of high-quality polyester curing agent Shenzhen PU wood pri

Foshan Hengrong ... 5 years

Shunde Distri...



¥ 192.00 Sold 0 pen

Wholesale dispersant Germany BYK-111 inorganic pigment dispersant c

Bao'an District of ... 4 years

Dongguan city



## Benefits of Direct Importing

According to China National Association of Engineering Consultants (2003) it,<sup>1</sup>

*...ensures Chinese paint producers have access to a **full set** of low-priced, high-quality material inputs, together with **good after sale service** from foreign providers. This can help Chinese paint producers to **improve their product quality** and competitiveness in the product markets.*

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<sup>1</sup>Translated from Chinese  
Grieco, Li, and Zhang

## Preliminary Evidence on Productivity and Trade

	OLS	A-B <sup>a</sup>	OLS	A-B <sup>a</sup>	OLS	A-B <sup>a</sup>
Import <sup>b</sup>	0.773 (0.054)	0.332 (0.220)			0.710 (0.058)	0.352 (0.227)
Export <sup>b</sup>			0.442 (0.053)	-0.090 (0.083)	0.128 (0.055)	-0.095 (0.083)
Lag Labor Prod.		0.136 (0.037)		0.134 (0.037)		0.135 (0.037)
Obs	5029	2880	5029	2880	5029	2880

<sup>a</sup> Arellano and Bond (1991) dynamic panel estimator, includes firm fixed effect.

<sup>b</sup> Import and export indicators lagged one year.

Dependent variable is log labor productivity. All regressions include year fixed effects. Robust standard errors in parentheses.

## Model Outline

1. Firm observes state: capital, productivity, input price, wage rate, trade status.
2. Static production decisions: labor, materials (quality and quantity), output.
3. Dynamic trade decisions: pay fixed/sunk cost to import/export next period.

## Demand

Firm physical output is  $Q_{jt} = Q_{jt}^X + Q_{jt}^D$  of quality  $\Phi_{jt}$  that is endogenously determined. Demand curves for Domestic and Export markets:

$$P_{jt}^D = (\Phi_{jt} Q_{jt}^D)^{1/\eta^D} = (\tilde{Q}_{jt}^D)^{1/\eta^D}$$

$$P_{jt}^X = \kappa (\Phi_{jt} Q_{jt}^X)^{1/\eta^X} = \kappa (\tilde{Q}_{jt}^X)^{1/\eta^X}$$

- ▶ Constant elasticity parameters  $\eta^D$  and  $\eta^X$  for domestic and export markets.
- ▶ Market size parameter  $\kappa$  captures relative size of domestic versus export market.
- ▶  $\tilde{Q}_{jt}$  captures quality adjusted output.
- ▶ Observe revenue with measurement error, e.g.,:

$$R_{jt}^D = \exp(u_{jt}^D) P_{jt}^D \tilde{Q}_{jt}^D$$

## Production

- ▶ CES production function for quality-adjusted output:

$$\tilde{Q}_{jt} = \tilde{\Omega}_{jt} \left[ \alpha_L L_{jt}^\gamma + \alpha_M M_{jt}^\gamma + \alpha_K K_{jt}^\gamma \right]^{\frac{1}{\gamma}},$$

- ▶  $\tilde{\Omega}_{jt}$  is firm “capability”, a function of productivity and input quality:

$$\tilde{\Omega}_{jt} = \left( \Omega_{jt}^\theta + H_{jt}^\theta \right)^{\frac{1}{\theta}}$$

- ▶ Firm productivity,  $\Omega_{jt}$  follows an endogenous Markov process depending on trade status.
- ▶ Input quality,  $H_{jt}$ , flexibly chosen by firm.
- ▶ Parameter  $\theta$  governs complementarity/substitutability of productivity and input quality.

## Choosing Input Quality

- ▶ Unit price of material is a function of firms' quality choice:

$$\tilde{P}_{Mjt} = P_{Mjt} H_{jt}^{\phi},$$

- ▶ Parameter  $\phi$  governs cost of raising quality.
- ▶ Input price  $P_{Mjt}$  is a state variable, evolves according to endogenous Markov process depending on trade status.
- ▶ Researcher observes  $E_{Mjt} = \tilde{P}_{Mjt} M_{jt}$ .

## Static Profit Maximization

Firms solve the following static problem in each period:

$$\pi(\Omega_{jt}, P_{Mjt}, P_{Ljt}, e_{jt}, K_{jt}) = \max_{L_{jt}, M_{jt}, H_{jt}, \tilde{Q}_{jt}^D, \tilde{Q}_{jt}^X} P_{jt}^D \tilde{Q}_{jt}^D + e_{jt} P_{jt}^X \tilde{Q}_{jt}^X - P_{Ljt} L_{jt} - \tilde{P}_{Mjt} M_{jt},$$

For exporters, problem must be solved numerically, but has a unique solution.

## Dynamic Decisions: Trade Participation

- ▶ Firms pay sunk/fixed costs to trade in following period.
- ▶ Exporting affects:
  - ▶ Future market access ( $e_{jt+1}$ ).
  - ▶ Future productivity.
- ▶ Importing affects:
  - ▶ Future material access (input prices,  $P_{Mjt}$ ).
  - ▶ Future productivity.



## Productivity and Input Price processes

- ▶ (Log) Productivity evolves according to Markov process that depends on trade status,

$$\omega_{jt+1} = f_t(\omega_{jt}, i_{jt}, e_{jt}) + \epsilon_{jt+1}^\omega$$

- ▶ (Log) input price process depends on import status,

$$p_{Mjt+1} = g_t(p_{Mjt}, i_{jt+1}) + \epsilon_{jt+1}^p$$

- ▶ Productivity and price innovations ( $\epsilon_{jt+1}^\omega, \epsilon_{jt+1}^p$ ) are uncorrelated with trade status, but may be correlated with each-other.
- ▶ Will show several specifications for productivity and input prices processes in estimation.

## Sunk and Fixed Costs of Trade Participation

- ▶ Let trade status be  $ie_{jt} = (i_{jt}, e_{jt})$ .
- ▶ In order to participate in trade next period, firm must pay a cost today:

$$\begin{aligned}C(ie_{jt+1}; ie_{jt}, \xi_{jt}) &= C(ie_{jt+1}, ie_{jt}; \lambda) - \lambda_{\xi} \xi_{jt}^{ie_{jt+1}} \\ &= \lambda_{ie_{jt+1}, ie_{jt}} - \lambda_{\xi} \xi_{jt}^{ie_{jt+1}}\end{aligned}$$

- ▶  $C(ie_{jt+1}, ie_{jt}; \lambda)$  contains constant part of sunk/fixed costs.
- ▶ Shock  $\xi_{jt}^{ie}$  is from Type I Extreme Value.
- ▶ The scale of cost shocks,  $\lambda_{\xi}$  can be estimated since static model identifies scale of profits.

## Dynamic Decisions: Trade Participation

- ▶ Observed state is  $s_{jt}$  where  $s_{jt} = (\Omega_{jt}, P_{Mjt}, P_{Ljt}, ie_{jt}, K_{jt})$
- ▶ Dynamic discrete choice problem.

$$V(s_{jt}, \xi_{jt}) = \max_{ie_{jt+1}} \{ \pi(s_{jt}) - C(ie_{jt+1}; ie_{jt}, \xi_{jt}) + \delta E_{s_{jt+1}} [V(s_{jt+1}, \xi_{jt+1}) | s_{jt}, ie_{jt+1}] \}$$

## Estimation strategy: Three Stages

Stage 1: estimate production parameters, quality-inclusive productivity  $\tilde{\omega}_{jt}$  and quality-inclusive price  $\tilde{p}_{Mjt}$ .

- ▶ Utilize the firm's static optimization of labor and material quantity choices (GLZ 2016).

Stage 2: recover productivity, quality-adjusted input prices, and their evolution processes.

- ▶ Utilize the firm's static optimization of material input quality choice and Markov assumptions.

Stage 3: Estimate sunk and fixed trade costs.

- ▶ Exploit conditional choice probabilities (Hotz & Miller 1993).

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## Stage 1: Production and Demand Parameters

- ▶ Following GLZ (2016), static input demand equations can be inverted to recover materials quantity:

$$M_{jt} = \left[ \frac{\alpha_L E_{Mjt}}{\alpha_M E_{Ljt}} \right]^{\frac{1}{\gamma}} L_{jt}$$

- ▶ Substitute into domestic revenue equation to estimate production parameters and domestic demand elasticity.
- ▶ Estimate export demand elasticity using exporters' revenue equation and earlier estimates.
- ▶ Finally, substitute all of above into labor demand and production function to solve for  $(\tilde{\omega}, \tilde{p}_M)$ .

▶ Details

## Stage 1: Production & Demand Estimates

parameter	estimate	parameter	estimate
$\eta^D$	-7.106 (0.383)	$\alpha_M$	0.883 (0.001)
$\eta^X$	-7.243 (1.322)	$\alpha_L$	0.054 (0.008)
$\gamma$	0.201 (0.057)	$\alpha_K$	0.063 (0.009)
$\kappa$	0.773 (0.376)		

Note: Bootstrap standard errors in parenthesis.

- ▶ Foreign market slightly more elastic.
- ▶ Highly materials-intensive, as expected.
- ▶ Elasticity of substitution  $\approx 1.25$  — for the paint industry.



## Stage 1: Quality-Inclusive Firm Heterogeneity

- ▶ Stage 1 recovers two endogenous variables due to quality choice:
  - ▶ Quality-inclusive firm capability,  $\tilde{\omega}_{jt}$ .
  - ▶ Quality-inclusive input price,  $\tilde{p}_{Mjt}$ .
- ▶ High correlation is consistent with high-productivity firms choosing high quality inputs (Kugler and Verhoogen 2012, De Loecker et al. 2016).

## Stage 2: Quality Choice, Productivity and Price Processes

Key assumptions:

1. Lagged productivity affects input prices only through quality choice.
2. Lagged quality adjusted input price does not affect current productivity.
3. Shocks to quality adjusted input price and productivity may be correlated.

## Stage 2: $\Omega_{jt}$ , $P_{Mjt}$ and their evolution process

- ▶ First order condition of input quality implies that input quality is a monotone function of productivity (in logs):

$$h_{jt} = \frac{1}{\theta} \ln \frac{\phi \sigma_{Mjt}}{1 - \phi \sigma_{Mjt}} + \omega_{jt}$$

- ▶ Use this in capability function and input price menu to recover (in logs),

$$\omega_{jt} = \tilde{\omega}_{jt} + \frac{1}{\theta} \ln(1 - \phi \sigma_{Mjt}).$$

$$p_{Mjt} = \tilde{p}_{Mjt} - \phi h_{jt}.$$

- ▶ Can compute  $\sigma_{Mjt}$ ,  $\tilde{\omega}_{jt}$ , and  $\tilde{p}_{jt}$  from data and stage 1. Estimate  $(\theta, \phi)$  using Markov assumption *a la* Olley and Pakes (1996). E.g.,

$$\omega_{jt+1} = f_0 + f_\omega \omega_{jt} + f_i i_{jt} + f_e e_{jt} + \epsilon_{jt+1}^\omega$$

$$p_{Mjt+1} = g_0 + g_p p_{Mjt} + g_i i_{jt+1} + \epsilon_{jt+1}^p$$

## Productivity Process

Parameter	I	II	III	IV	V
$\theta$	-0.249 (0.090)	-0.244 (0.080)	-0.250 (0.084)	-0.247 (0.085)	-0.248 (0.082)
$\phi$	0.985 (0.008)	0.982 (0.010)	0.986 (0.009)	0.985 (0.009)	0.985 (0.009)
Intercept, $f_0$	2.343 (1.948)	2.507 (0.992)	2.343 (1.198)	2.655 (2.520)	2.654 (1.370)
Export, $f_e$	0.087 (0.050)	0.077 (0.060)	0.087 (0.059)	0.102 (0.045)	0.102 (0.050)
Import, $f_i$	0.264 (0.055)	0.268 (0.058)	0.263 (0.059)	0.265 (0.055)	0.265 (0.053)
WTO, $f_{wto}$	0.185 (0.048)		0.185 (0.057)		
Lag, $f_\omega$	0.640 (0.038)	0.641 (0.041)	0.640 (0.052)	0.638 (0.071)	0.638 (0.053)
Year dummies	No	No	No	Yes	Yes

## Productivity Process Highlights

- ▶ Significant complementarity between input quality and productivity,  $\theta < 0$ .
- ▶ Higher quality inputs are more costly.
- ▶ Trade has positive effect on productivity, importing raises productivity more than exporting.

## Input Price Process

Parameter	I	II	III	IV	V
Intercept, $g_0$	0.623 (0.146)	0.655 (0.110)	0.645 (0.104)	0.558 (0.115)	0.578 (0.104)
Export, $g_e$		-0.006 (0.005)	-0.006 (0.005)		-0.006 (0.005)
Import, $g_i$		-0.021 (0.005)			
Import, pre-WTO, $g_{i0}$	-0.018 (0.010)		-0.017 (0.010)	-0.015 (0.014)	-0.014 (0.012)
Import, post-WTO, $g_{i1}$	-0.024 (0.005)		-0.022 (0.005)	-0.025 (0.005)	-0.023 (0.005)
WTO, $g_{wto}$	-0.020 (0.007)		-0.020 (0.007)		
Lag, $f_p$	0.939 (0.010)	0.934 (0.010)	0.937 (0.009)	0.943 (0.010)	0.941 (0.009)
Year dummies	No	No	No	Yes	Yes

# Input Price Process Highlights

- ▶ Importing directly lowers (quality adjusted) input prices
- ▶ Effect gets larger after WTO accession
- ▶ Exporting has no effect on input prices.
- ▶ Input price process is much more persistent than productivity process.

▶ Productivity Distribution and Quality Adjustment

## Allocation of Sales by Productivity and Input Prices

We can examine how aggregate productivity and input price have changed in our data following the decomposition in Olley and Pakes (1996).

Let weight  $w_{jt} = R_{jt} / \sum_k R_{kt}$ ,

$$\Omega_t = \bar{\Omega}_t + \sum_j (w_{jt} - \bar{w}_t)(\Omega_{jt} - \bar{\Omega}_t) = \bar{\Omega}_t + \sum_j \Delta w_{jt} \Delta \Omega_{jt},$$

- ▶ Decomposition indicates whether change in aggregate productivity is due to change in unweighted mean or allocation of output across firms.
- ▶ Similar decomposition can be performed for input prices.



## Productivity

Year	Weighted	Unweighted	Cov.
2000	1.00	0.82	0.18
2001	0.92	0.64	0.28
2002	1.00	0.69	0.31
2003	1.19	0.72	0.47
2004	1.45	0.73	0.73
2005	1.30	0.80	0.49
2006	1.64	1.04	0.60

- ▶ More productive firms sell more.
- ▶ Correlation grows during data period, and is responsible for most of aggregate productivity growth.

## Input Price

Year	Weighted	Unweighted	Cov.
2000	1.00	1.29	-0.29
2001	1.01	1.32	-0.31
2002	1.02	1.30	-0.28
2003	0.97	1.28	-0.31
2004	0.99	1.30	-0.31
2005	0.96	1.29	-0.32
2006	0.92	1.25	-0.33

- ▶ Input prices have declined, but magnitude is smaller.
- ▶ Firms that sell more have lower input prices.

## Stage 3: Fixed and Sunk Trade Costs

So far, we've estimated 4 benefits of trade participation:

- ▶ Access to export market (higher total revenue).
- ▶ Productivity gains from exporting.
- ▶ Access to import market (lower quality-adjusted prices).
- ▶ Productivity gains from importing.

We use these together with firm decisions to estimate the sunk and fixed costs of trade.

## Stage 3: Estimation Overview (CCP)

1. State  $s$  is fully observed  $s_{jt} = (ie_{jt}, \Omega_{jt}, P_{Mjt}, P_{Ljt}, K_j)$  as is import/export decision  $ie_{jt+1}$ .
2. Estimate the choice probability.  $\Pr(ie_{jt+1}|s_{jt})$  directly from data.
3. The value of selecting choice  $ie_{jt+1}$  and then following optimal strategy is,

$$\begin{aligned}
 V(s_{jt}, \xi_{jt}|ie_{jt+1}; \lambda) &= \pi(s_{jt}) - C(ie_{jt+1}, ie_{jt}; \lambda) + \lambda_{\xi} \xi_{jt}^{ie_{jt+1}} \\
 &\quad + \delta E[V(s_{jt+1}, \xi_{jt+1})|s_{jt}, ie_{jt+1}] \\
 &\equiv V^{\xi}(s_{jt}|ie_{jt+1}; \lambda) + \lambda_{\xi} \xi_{jt}^{ie_{jt+1}}
 \end{aligned}$$

4. Expectation is over transition processes and future trade cost shocks, compute  $V^{\xi}(s_{jt}|ie_{jt+1}; \lambda)$ , use forward simulation.
5. Find trade costs that rationalize observed choices of firms.

## Stage 3: Estimating Trade Costs

- ▶ Predicted choice probability given  $\lambda$  is,

$$\Pr\{ie_{jt+1}|s_{jt}, \lambda\} = \frac{\exp(V^\xi(s_{jt}|ie_{jt+1}; \lambda)/\lambda_\xi)}{\sum_{ie} \exp(V^\xi(s_{jt}|ie_{jt+1}; \lambda)/\lambda_\xi)}.$$

- ▶ Minimize distance between observed policy and policy implied by  $\lambda$ :

$$\hat{\lambda} = \underset{\lambda}{\operatorname{argmin}} \sum_{j,t} \sum_{ie'} \left\{ \frac{1}{\lambda_\xi} [V^\xi(s_{jt}|ie_{jt+1}; \lambda) - V^\xi(s_{jt}|ie'; \lambda)] - \left[ \ln \hat{\Pr}(ie_{jt+1}|s_{jt}) - \ln \hat{\Pr}(ie'|s_{jt}) \right] \right\}^2.$$

## Sunk and Fixed Costs of Trade

Parameter	Estimate	Parameter	Estimate
$\lambda_{00,01}$	5.519 (0.721)	$\lambda_{01,01}$	0.084 (0.087)
$\lambda_{00,10}$	7.141 (0.992)	$\lambda_{01,10}$	5.928 (0.994)
$\lambda_{00,11}$	11.518 (1.606)	$\lambda_{01,11}$	5.857 (0.939)
$\lambda_{10,01}$	4.012 (0.626)	$\lambda_{11,01}$	0.966 (0.324)
$\lambda_{10,10}$	0.152 (0.101)	$\lambda_{11,10}$	0.319 (0.325)
$\lambda_{10,11}$	4.138 (0.652)	$\lambda_{11,11}$	0.068 (0.087)
$\lambda_{\xi}$	4.808 (3.028)		

## Sunk and Fixed Costs of Trade

- ▶ Persistence due to large sunk cost (relative to fixed cost).
- ▶ Some complementarity between importing and exporting for both fixed and sunk costs.
- ▶ Check fit by comparing
  - ▶ Raw choice probabilities
  - ▶ Choice probability estimates.
  - ▶ Choice probabilities implied by the structural model at estimates.

# Counterfactual Analysis

Questions:

1. How important are productivity and input price incentives to trade?
2. How to these incentives affect aggregate input price/productivity levels?
3. Does liberalization's benefit to direct importers lead to increase in trade?
4. How does it change the distribution of productivity, valuations?

How? Four counterfactuals:

1. Eliminate productivity benefit of trade.
2. Eliminate input price benefits of importing.
3. Reduce input price benefit to pre-WTO level.
4. (3) with firms' trade participation policy fixed.



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## Comparing the Mechanisms: Productivity VS Input prices

Suppose trade status does not effect: 1) productivity; 2) input prices.

Year	2	5	10	15
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### 1. Eliminate Productivity Benefit

Aggregate productivity (percent)	-26.4	-34.9	-39.6	-39.7
Aggregate input price (percent)	0.6	1.1	1.6	2.1
Proportion of exporters (percentage points)	-0.6	-1.4	-2.4	-3.3
Proportion of importers (percentage points)	-1.0	-2.2	-4.0	-5.4
Firm value (percent and million USD)		-4.2	(-5.2)	

### 2. Eliminate Input Price Benefit

Aggregate productivity (percent)	-4.1	-10.7	-21.4	-25.4
Aggregate input price (percent)	2.6	5.3	7.4	8.2
Proportion of exporters (percentage points)	-0.6	-1.7	-3.0	-4.0
Proportion of importers (percentage points)	-1.8	-3.9	-6.8	-9.0
Firm value (percent and million USD)		-6.4	(-7.2)	

## WTO Counterfactual

Question: Did tariff liberalization change the incentive to import, and consequently affect firm values and aggregate productivity?

- ▶ WTO accession increased the price benefit of importing.
- ▶ How did this change in the import price premium affect firm performance?
  - ▶ Full effect: Firms to re-optimize trade policies based on lower imported input prices.
  - ▶ Direct effect: Firms follow old policy, but experience lower prices for imported inputs.
- ▶ For this analysis we hold the impact of WTO though import competition fixed—focus only on gap in input price between importers and non-importers.

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## Effect of WTO Incentive to Import

Year	2	5	10	15
<b>Full Effect</b> (firms re-optimize trade policy)				
Aggregate Productivity (percent)	1.0	3.1	7.0	8.6
Aggregate Input price (percent)	-0.7	-1.6	-2.4	-2.8
Exporters (percentage point)	0.2	0.5	1.0	1.4
Importers (percentage point)	0.5	1.2	2.2	3.0
Valuation (percent and million USD)		2.3 (2.4)		
<b>Direct Effect</b> (firms do not update trade policy)				
Aggregate productivity (percent)	0.8	1.7	3.3	3.9
Aggregate input price (percent)	-0.6	-1.3	-1.9	-2.1
Exporters (percentage)	0.0	0.0	0.2	0.2
Importers (percentage)	0.0	0.1	0.3	0.5
Valuation (Percent, million USD)		2.1 (2.2)		



## Effect of WTO Incentive to Import

- ▶ Tariff cut induces large gain in aggregate productivity:
  - ▶ Most of gain occurs between years 5 and 15.
  - ▶ Most of gain due to firms endogenous response to policy change.
- ▶ Effect on firm valuations is more muted because firms are paying substantial trade costs.
- ▶ Import liberalization increases both importing and exporting due to interactions of input prices, productivity, and trade participation.

## On Allocation: Effect of WTO Incentive to Import

	Weighted	Unweighted	Cov.
Productivity	8.6	2.3	6.3
Input Price	-2.8	-1.4	-1.4

- ▶ Higher productivity and lower input price are largely due to reallocation of output towards higher performing firms.
- ▶ This is intuitive:
  - ▶ Tariff cut benefits firms that choose to import.
  - ▶ Importers tend to be higher performing firms.

## Which Firms Benefit?

Breakdown of 15-year effects by productivity and trade status in initial period:

	Low $\omega$	High $\omega$	Neither	Export Only	Import Only	Both
Productivity (%)	3.6	5.5	3.1	8.1	5.9	5.8
Input price (%)	-1.6	-3.0	-0.8	-2.6	-5.1	-5.7
Exporting	1.1	1.7	0.9	2.8	4.9	5.0
Importing	2.6	3.3	2.0	4.9	9.1	8.8
Firm value (\$M )	1.9	2.8	1.3	3.3	8.0	10.8

## WTO Counterfactual Summary

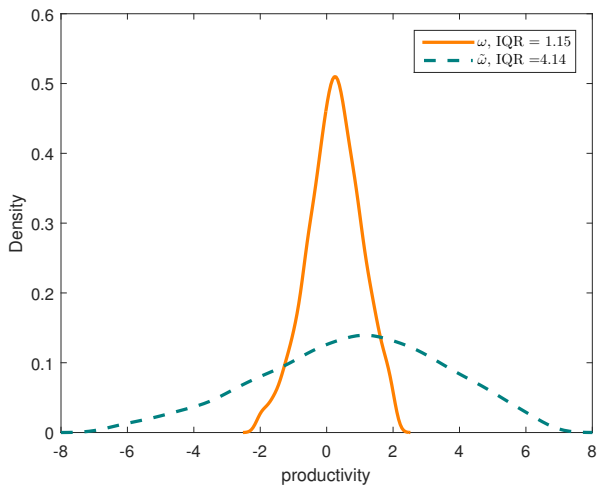
- ▶ Overall, tariff liberalization resulted in 2.3 percent gain in firm value.
- ▶ Firm productivity increase of 8.6 percent over 15 years due to liberalizations incentive for direct importing.
  - ▶ Small relative to total productivity gains of Chinese firms during this period.
  - ▶ But this productivity effect would not be captured in static trade liberalization models.
- ▶ Gains are larger for more productive firms, firms that are already trading.

## Conclusion

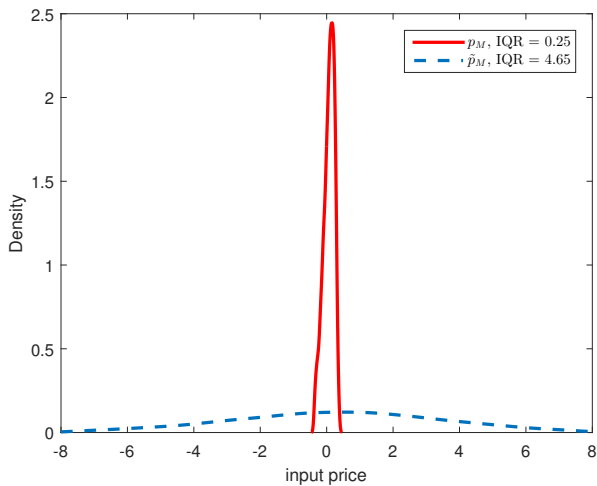
**Separating** input prices and productivity, and considering **dynamic** implications of trade participation illustrates **direct importing** channel of effect of tariff liberalization on firm performance.

- ▶ Direct importing boosts productivity and lowers input prices.
- ▶ Liberalizing input tariffs encourages trade participation.
- ▶ Policy effects accrue slowly over time due dynamic participation decision.
- ▶ Benefits are not shared equally, accentuation correlation between output and productivity.

# Productivity Distribution



# Input Price Distribution



## Input Imports and Output Exports

**Table:** Largest Import Origins and Export Destinations.

Country	Origins		Destinations		
	Value	Share	Country	Value	Share
Taiwan	96	15.7	Hong Kong	112	47.7
Japan	93	15.1	Korea	23	9.9
USA	86	14.1	Japan	11	4.8
Germany	70	11.5	Taiwan	9	3.9
Korea	69	11.2	Vietnam	7	3.2

Note: The value is average by year, in million USD. Share is in percent.



## Stage 1: production and demand parameters

Estimating  $\alpha, \gamma, \eta^D$ :

For domestic firms  $R^X = 0$ , and parameters can be estimated exactly as in GLZ (2016). Substituting out  $h_{jt}$  and  $M_{jt}$ , revenue equation is,

$$\log(R_{jt}^D) = \log\left(\frac{\eta^D}{1 + \eta^D}\right) + \log\left[E_{M_{jt}} + E_{L_{jt}} \left(1 + \frac{\alpha_K}{\alpha_L} \left(\frac{K_{jt}}{L_{jt}}\right)^\gamma\right)\right] + u_{jt}^D.$$

Cross-section restrictions to help recover all parameters:

- ▶ Normalization:  $\alpha_L + \alpha_M + \alpha_K = 1$
- ▶ Aggregating firm FOCs:  $\frac{\bar{E}_L}{\bar{E}_M} = \frac{\alpha_L}{\alpha_M}$ .

Still need to estimate  $\eta^X$ .

## Stage 1: production and demand parameters

Estimating  $\eta^X$ :

- ▶ Estimate  $\eta^X$  using exporting firms. Note that,

$$\log(R_{jt}^X) = (1 + \eta^X) \log\left(\frac{\eta^X}{\hat{\eta}^D} \frac{1 + \hat{\eta}^D}{1 + \eta^X}\right) + \frac{1 + \eta^X}{1 + \hat{\eta}^D} \log(R_{jt}^D) + u_{jt}, \quad (1)$$

where  $u_{jt} = (u_{jt}^X + \frac{1 + \eta^X}{1 + \hat{\eta}^D} u_{jt}^D)$ .

- ▶  $R_{jt}^D$  is correlated with  $u_{jt}$  but we can use inputs as instruments  $(K_{jt}, L_{jt})$
- ▶ With production and demand parameters estimated, we can recover firm heterogeneity  $(\hat{P}_{M_{jt}}, \hat{h}_{jt})$ .
- ▶ However, these are not primitives, but functions of endogenously chosen input quality.

## Stage 1: Elasticity of Substitution

Cobb-Douglas assumes elasticity of substitution is exactly 1.

Cross-industry studies often find elasticities below 1, we find 1.25.

- ▶ Similar magnitude to Berkowitz et al. (forthcoming) using value added production function on Chinese manufacturing firms.
- ▶ High substitutability consistent with waste.
- ▶ We've found failure to account for input price heterogeneity biases substitutability downward in Monte Carlo (GLZ 2016).
- ▶ On the other hand, adjustment costs to labor or materials may bias substitution parameter upwards.

▶ Back