Imported Inputs, Quality Complementarity, and Skill Demand

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Motivation

- How does trade affect firms and their use of productive resources?
  - Export-driven reallocation of resources to more productive firms (Melitz, 2003)
  - Imported inputs also important driver of firm productivity (Amiti and Konings, 2007; Goldberg et al., 2010). Input quality probably important driver.
- Rich (skill-abundant) countries supply high-quality varieties (Schott, 2004; Hummels and Klenow, 2005; Hallak, 2006)

Existing literature

- Work on heterogenous product quality focuses on *output* (Bastos and Silva, 2010; Manova and Zhang, 2012)
- Models with heterogenous *inputs* typically do not analyze quality dimension (Grossman and Rossi-Hansberg, 2008; Costinot and Vogel, 2010)

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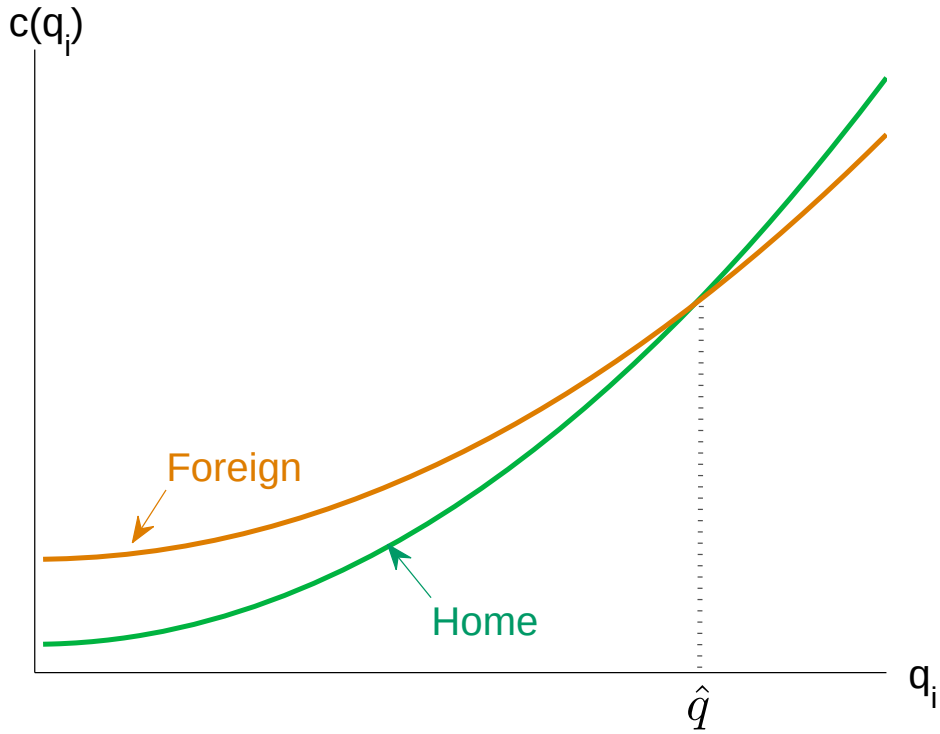
This Paper – Theory

- Heterogenous input quality
- Quality complementarity across inputs (O-Ring)
- Developing countries have cost advantage at producing low-quality inputs
- Two opposing effects:
  - Substitution effect: Firms in developing countries substitute domestic quality-sensitive inputs (skilled labor) with imported inputs ("quality fragmentation of production")
  - Complementarity effect: Higher-quality inputs $\Rightarrow$ higher quality/skill demand for remaining domestic inputs

Cost of input quality in domestic and foreign market



This Paper – Empirics

- Combine Chilean plant-level panel with customs data on imports and exports
- Calculate two indicators for 'quality' of imports:
  - Price relative to all other importers of the same (8-digit) product
  - Skill intensity of import production in the U.S.
- Evidence in line with model predictions:
  - Importing firms use higher-quality domestic inputs (both physical inputs and labor) and produce higher-quality output
  - Firms that import inputs use a smaller proportion of white-collar labor, but:
  - High-quality imports are associated with more skill demand

Examples

- Embraer in Brazil: Uses large share of imported inputs. One reason for success: Import tariff exemption (military firm)
- From a case study on Embrear and other Brazilian firms (Bernardes, 2003)
  - "Firms are scaling down local R&D,...effort shifted into the more simple adaptation of imported processes and products"
  - "highly-qualified engineers engaged in R&D transferred to other, less-specialized functions, such as production, quality assurance, sales or marketing"

Related Literature – Broader

- Firm level effects of trade:
  - Re-allocate market shares towards exporters (Pavcnik, 2002 REStud; Melitz, 2003 ECMA). Rising revenues foster investment in technology (Bustos, 2011 AER)
  - Workers using imported machines in Hungarian firms earn higher wages (Csillag and Koren, 2011)
  - In general: Selection of firms more important than within-firm effects
- Trade integration leads to rising skill demand in developed *and* developing countries (Goldberg and Pavcnik, 2007 JEL) $\Rightarrow$ in contrast to standard trade theory
- Theories on how import of skill-biased capital raises *aggregate* skill demand (Burstein et al. 2011; Parro, 2011)

Related Literature – Imported Inputs; Product Quality

- Strong evidence that inputs from international markets affect firms in developing countries:
  - Raise firm productivity (Amiti and Konings 2007, AER)
  - New intermediates due to trade promote domestic product growth (Goldberg et al., 2010 QJE)
  - Foster introduction of new products (Goldberg et al. 2010, QJE)
  - Increase profits (De Loecker et al., 2012)
  - Important channel: Higher quality of imported inputs
- Trade and product quality:
  - Complementarity between input and output quality (Kugler and Verhoogen, 2012 REStud)
  - Higher output quality associated with higher skill demand (Verhoogen, 2008 QJE)

Model – Overview

- Continuum of variety-producers: $\omega \in \Omega$
  - Produce output of quality $Q(\omega)$
  - Quantity demanded $x(\omega)$ increases in quality
- Each firm ω uses continuum of inputs i
  - Heterogenous input quality $q_{i\omega}$
  - Quality-complementarity across inputs (CES over input quality $q_{i\omega}$)
  - Can interpret domestic inputs as labor (quality $\sim$ skills)
- Partial equilibrium model
  - Given cost function of input quality
  - Input and output quality endogenously determined

Quality Prd Fct More Detail

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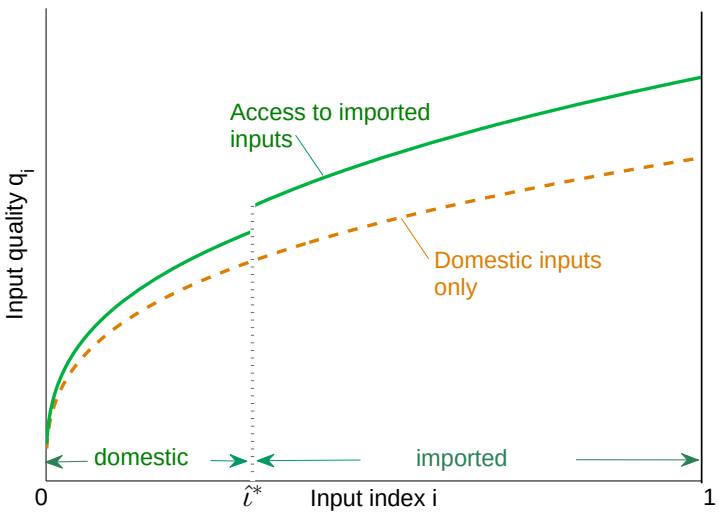
▸ Quality Prd Fct ▸ More Detail

Optimal choice of input quality

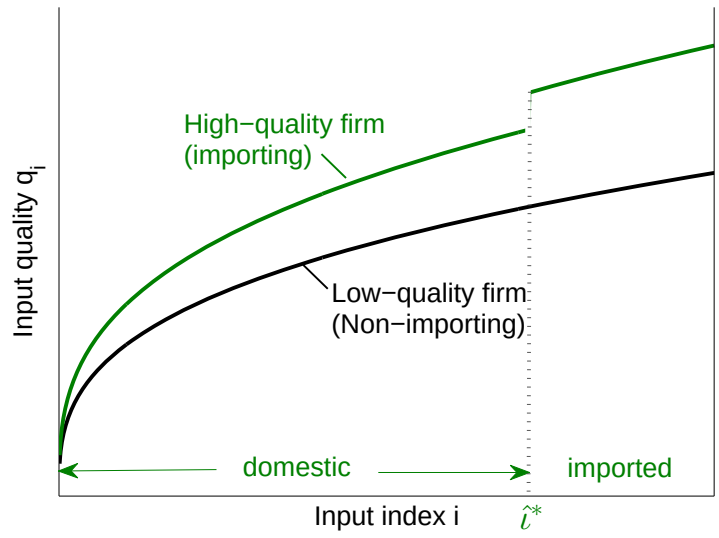
Within firms

(with/without access to imported inputs)

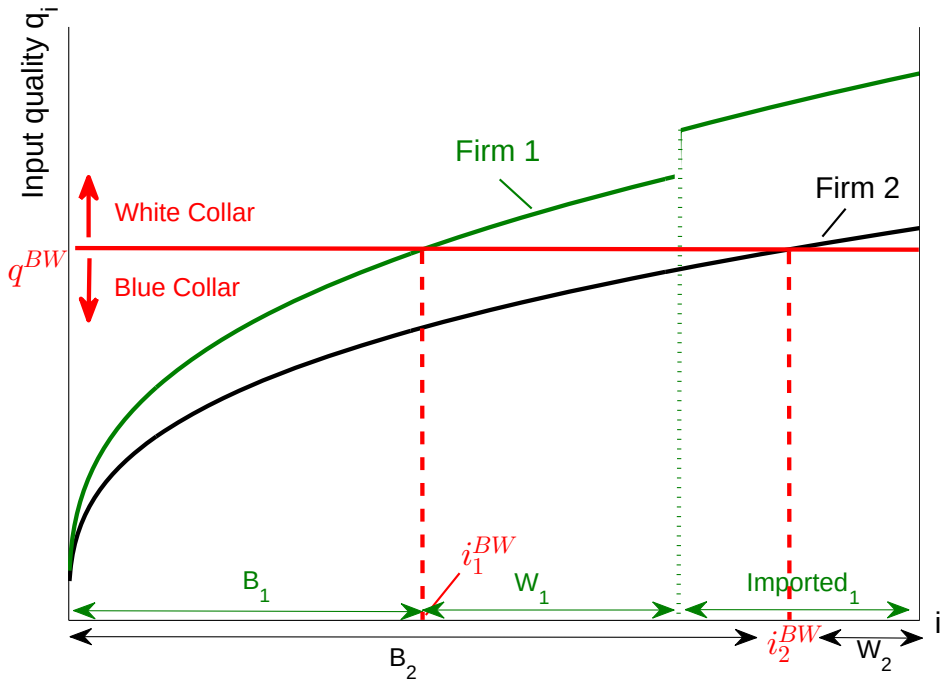


Across firms

(comparing high- and low-quality firm)



Mapping the model to the data: white collar (W) and blue-collar (B) workers



Model Predictions – Summary

Importing firms in a developing country...

1. ...produce high-quality output
2. ...use higher-quality domestic inputs
3. ...c.p. use a smaller share of skilled workers than non-importing firms, but this effect is alleviated when controlling for imported input quality
4. ...will pay higher wages if the complementarity effect is strong

Empirical Results – Data

Main Dataset: ENIA

- Census of Chilean plants with more than 10 employees. About 4,500 plants between 1992-2005
- Observations on large set of firm-level variables. Most importantly:
  - Various categories of skilled workers: Managers, Specialized workers in the productive process, Administrative Staff and "Empleados a comision"
  - Capital stock, domestic inputs, sales, value added, etc.
  - Output prices

Combine with Chilean Customs data

- Value of imported product j purchased by firm i in year t from country of origin c
- Product j measured at HS-8 level
- Tariff associated with imp_{ijtc}

▸ Replication of stylized facts ▸ Tariffs over time

Import Quality Indicators

1. Import Price Index (from customs data)
2. Import Skill Intensity (using U.S. manufacturing data)

Detail

Prediction 1

Importing firms produce higher-quality output

$$\ln(P_{ikjt}^{out}) = d_{it}^{imp} + \beta\theta_{it}^{imp} + \gamma X_{ijt} + \alpha_{st} + \alpha_{kjt} + \alpha_r + \varepsilon_{ijt}$$

Where

- P_{ikjt}^{out}: price at which firm i sells output product k, measured in unit j, in year t
- d_{it}^{imp}: importer dummy
- θ_{it}^{imp}: indicator for quality of imported inputs
- X_{ijt}: vector of control variables
- α_{st}: Sector (3-digit) – year FE
- α_{kjt}: Product (8-digit) – unit – year FE
- α_r: Region dummies

Prediction 1 – Results

Importing firms produce higher-quality output

	(1)	(2)	(3)	(4)‡	(5)	(6)
	PANEL A: Dependent Variable: ln(output price)					
ln(workers)	.0535***					.0201*
	(.009)					(.011)
Export dummy		.116***			.0933***	.0358
		(.026)			(.027)	(.031)
Import dummy			.0834***		.0487**	- .0157
			(.022)		(.023)	(.027)
Import price index				.0694***	.0741***	.0599***
				(.015)	(.014)	(.015)
Further controls						✓
Product-Year FE	✓	✓	✓	✓	✓	✓
Sector-Year FE	✓	✓	✓	✓	✓	✓
Region dummies	✓	✓	✓	✓	✓	✓
R^2	.141	.14	.14	.146	.141	.147
Observations	101,572	101,572	101,572	49,578	101,572	87,058

Prediction 2

Importing firms use higher-quality domestic inputs

$$\ln(P_{ikjt}^{dom}) = d_{it}^{imp} + \beta \cdot \theta_{it}^{imp} + \gamma X_{ijt} + \alpha_{st} + \alpha_{kjt} + \alpha_r + \varepsilon_{ijt}$$

Where

- P_{ikjt}^{dom}: price paid by firm i for domestic input k , measured in unit j, in year t
- d_{it}^{imp}: importer dummy
- θ_{it}^{imp}: indicator for quality of imported inputs
- X_{ijt}: vector of control variables
- α_{st}: Sector (3-digit) – year FE
- α_{kjt}: Product (8-digit) – unit – year FE
- α_r: Region dummies

Prediction 2 – Results

Importing firms use higher-quality domestic inputs

PANEL B: Dependent Variable: ln(domestic input price)

ln(workers)	.0477***					.0451***
	(.008)					(.010)
Export dummy		.0732***			.0592***	.00357
		(.021)			(.023)	(.025)
Import dummy			.0530***		.0284	- .0153
			(.018)		(.018)	(.022)
Import price index				.0506***	.0484***	.0394***
				(.012)	(.012)	(.013)
Further controls						✓
Product-Unit-Year FE	✓	✓	✓	✓	✓	✓
Sector-Year FE	✓	✓	✓	✓	✓	✓
Region dummies	✓	✓	✓	✓	✓	✓
R^2	.067	.066	.066	.061	.067	.069
Observations	276,358	276,358	276,358	137,985	276,358	234,130

Prediction 3

Importing firms (i) use c.p. a smaller share of skilled workers than non-importing firms, (ii) this effect is alleviated when controlling for imported input quality

$$h_{ist} = d_{it}^{imp} + \beta \cdot \theta_{it}^{imp} + \gamma X_{ijt} + \alpha_{st} + \alpha_r + \varepsilon_{ijt}$$

Where

- h_{ist}: share of skilled workers in firm i in sector s, year t
- d_{it}^{imp}: importer dummy
- θ_{it}^{imp}: indicator for quality of imported inputs
- X_{ijt}: vector of control variables
- α_{st}: Sector (3-digit) – year FE
- α_r: Region dummies

Prediction 3 – Results for Import Price Index

Importing firms (i) use c.p. a smaller share of skilled workers than non-importing firms, (ii) this effect is alleviated when controlling for imported input quality

Dependent variable: Firm-level skilled labor share, h_{it}.

Sample	Importers only			All firms		
	(1)	(2)	(3)	(4)	(5)	(6)
Import price index θ_{it}^{Imp}	.00988***	.00711***	.00713***	.00966***	.00717***	.00772***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
Import share Imports_{it} / Sales_{it}	-.0348**	-.0504***	-.0469***	-.0321**	-.0538***	-.0460***
	(.014)	(.015)	(.016)	(.014)	(.015)	(.015)
Capital per worker $\ln(k_{it})$	.0173***	.0202***	.0212***	.0235***	.0249***	.0281***
	(.003)	(.004)	(.004)	(.003)	(.004)	(.004)
Productivity ln(VA per worker_{it})	.0301***	.0292***	.0288***	.0195***	.0212***	.0206***
	(.003)	(.004)	(.004)	(.003)	(.003)	(.003)
Interm. Input share Inputs_{it}^{int} / Sales_{it}	-.0128	.00884	.0120	-.0392***	-.00111	-.00182
	(.012)	(.012)	(.012)	(.010)	(.009)	(.010)
Foreign owner	.0187**	.0228***	.0218***	.0199***	.0284***	.0283***
	(.008)	(.008)	(.008)	(.008)	(.007)	(.007)
Importer Dummy d_{it}^{Imp}				-.0377***	-.0302***	-.0309***
				(.004)	(.004)	(.004)
Region-Year FE		✓	✓		✓	✓
Sector FE		✓	✓		✓	✓
Sector-Year FE			✓			✓
R^2	.077	.116	.164	.084	.116	.146
Observations	24,949	24,949	24,949	53,351	53,351	53,351

Prediction 3 – Results for Import Skill Intensity

Importing firms (i) use c.p. a smaller share of skilled workers than non-importing firms, (ii) this effect is alleviated when controlling for imported input quality

Dependent variable: Firm-level skilled labor share, h_{it}.

Sample	Importers only			All firms		
	(1)	(2)	(3)	(4)	(5)	(6)
Import skill intensity σ_{it}^{Imp}	.223***	.186***	.176***	.175***	.133***	.143***
	(.045)	(.050)	(.052)	(.045)	(.048)	(.049)
Import share Imports$_{it}$ / Sales$_{it}$	-.0363**	-.0504***	-.0472***	-.0359**	-.0557***	-.0480***
	(.015)	(.015)	(.016)	(.014)	(.015)	(.015)
Capital per worker ln (k_{it})	.0174***	.0201***	.0210***	.0236***	.0249***	.0281***
	(.003)	(.004)	(.004)	(.003)	(.004)	(.004)
Productivity ln(VA per worker$_{it}$)	.0294***	.0297***	.0293***	.0193***	.0213***	.0208***
	(.003)	(.004)	(.004)	(.003)	(.003)	(.003)
Interm. Input share Inputs$_{it}^{int}$ / Sales$_{it}$	-.0138	.00883	.0118	-.0399***	-.00151	-.00231
	(.012)	(.012)	(.012)	(.010)	(.009)	(.010)
Foreign owner	.0164**	.0219***	.0209***	.0183**	.0277***	.0275***
	(.008)	(.008)	(.008)	(.008)	(.007)	(.007)
Importer Dummy d_{it}^{Imp}				-.107***	-.0832***	-.0878***
				(.018)	(.020)	(.020)
Region-Year FE		✓	✓		✓	✓
Sector FE		✓	✓		✓	✓
Sector-Year FE			✓			✓
R^2	.077	.116	.164	.084	.115	.146
Observations	24,949	24,949	24,949	53,351	53,351	53,351

Interaction with Import Share

Dependent variable is the firm-level skilled labor share, h_{it}.

Import quality measure	Import price index (θ_{it}^{Imp})			Import skill intensity (σ_{it}^{Imp})		
Sample	Importers only		All firms	Importers only		All firms
	(1)	(2)	(3)	(4)	(5)	(6)
Import Quality θ_{it}^{Imp} / σ_{it}^{Imp}	.00604***	.00513**	.00577***	.145***	.119**	.082
	(.002)	(.002)	(.002)	(.055)	(.058)	(.054)
Imports/Sales	.0103	-.0374**	-.0345**	-.179**	-.240**	-.261***
	(.013)	(.015)	(.015)	(.083)	(.098)	(.097)
Imp. Qual. × (Imp/Sales)	.0227*	.0277*	.0270*	.459**	.492**	.549**
	(.013)	(.015)	(.014)	(.208)	(.243)	(.243)
Capital per worker $\ln(k_{it})$		.0219***	.0285***		.0217***	.0285***
		-(.004)	-(.004)		-(.004)	-(.004)
Productivity ln(VA per worker$_{it}$)		.0305***	.0221***		.0308***	.0222***
		(.004)	(.003)		(.004)	(.003)
Interm. Input share Inputs$_{it}^{int}$ / Sales$_{it}$		.0169	.000934		.0159	.000186
		(.013)	(.010)		(.012)	(.010)
Importer Dummy d_{it}^{Imp}			-.0303***			-.0621***
			(.004)			(.022)
Region FE	✓	✓	✓	✓	✓	✓
Sector-Year FE	✓	✓	✓	✓	✓	✓
R^2	.13	.16	.14	.14	.16	.14
Observations	27,692	24,949	53,351	27,692	24,949	53,351

Further Controls: Exports and Domestic Inputs

Dependent variable is the firm-level skilled labor share, h_{it}.

Import quality measure	Import price index (θ_{it}^{Imp})			Import skill intensity (σ_{it}^{Imp})		
Sample	Importers only		All firms	Importers only		All firms
	(1)	(2)	(3)	(4)	(5)	(6)
Import quality θ_{it}^{Imp}	.00782***	.00776***	.00913***	.198***	.197***	.184***
	(.002)	(.002)	(.002)	(.049)	(.049)	(.046)
Export quality index θ_{it}^{Exp}	.00205	.00202	.00157	.00243	.00239	.00194
	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
Domestic input price index θ_{it}^{Dom}		.00305	.00269		.00311	.00277
		(.002)	(.002)		(.002)	(.002)
Exporter Dummy d_{it}^{Exp}	.0000845	.000164	-.00264	.000717	.000788	-.00234
	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)
Domestic Input Dummy d_{it}^{Dom}		-.00195	-.00723		-.00163	-.0071
		(.006)	(.005)		(.006)	(.005)
Importer Dummy d_{it}^{Imp}			-.0163***			-.0898***
			(.004)			(.019)
Region FE	✓	✓	✓	✓	✓	✓
Sector-Year FE	✓	✓	✓	✓	✓	✓
R^2	.133	.133	.126	.133	.133	.126
Observations	29,193	29,193	63,987	29,193	29,193	63,987

Effects over Time

Dependent variable: Firm-level skilled labor share, h_{it}.

Sample	Importers only			All firms		
	(1)	(2)	(3)	(4)	(5)	(6)
Import price index θ_{it}^{Imp}	-.00583**	-.00731**	-.00583**	-.00621**	-.00542**	- .00381
	(.003)	(.003)	(.003)	(.003)	(.002)	(.002)
Years as importer Y^{Imp}	-.00378***	-.00299**	-.00362***	-.00578***	-.00780***	-.00565***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Interaction $\theta_{it}^{Imp} \times Y^{Imp}$	.00302***	.00152***	.00124**	.00324***	.00142***	.00116**
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Importer Dummy d_{it}^{Imp}				.0136***	.0191***	.0132***
				(.004)	(.004)	(.005)
Region FE	✓	✓	✓	✓	✓	✓
Sector-Year FE	✓		✓	✓		✓
Firm FE		✓	✓		✓	✓
R^2	.14	.57	.54	.13	.56	.51
Observations	29,193	29,193	29,193	63,987	63,987	63,987

Prediction 4 – Wages as Dependent Variable

If the complementarity effect is strong, importing firms pay higher wages

Dependent variable: Firm-level wages.

	Importers only			All firms		
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	ln(wage)	ln(wage^W)	ln(wage^B)	ln(wage)	ln(wage^W)	ln(wage^B)
Import price index θ_{it}^{Imp}	.0289*** (.005)	.0202*** (.006)	.0250*** (.004)	.0294*** (.005)	.0227*** (.006)	.0263*** (.004)
Import share Imports_{it} / Sales_{it}	.295*** (.037)	.307*** (.043)	.189*** (.032)	.316*** (.035)	.301*** (.042)	.202*** (.031)
Capital per worker $\ln(k_{it})$	.130*** (.011)	.0805*** (.011)	.0995*** (.010)	.0880*** (.007)	.0458*** (.009)	.0700*** (.007)
Interm. Input share Inputs_{it}^{int} / Sales_{it}	-.190*** (.031)	-.227*** (.038)	-.166*** (.029)	-.260*** (.021)	-.314*** (.027)	-.226*** (.020)
Foreign owner Inputs_{it}^{int} / Sales_{it}	.224*** (.023)	.220*** (.024)	.133*** (.020)	.240*** (.022)	.234*** (.023)	.147*** (.019)
Export quality index θ_{it}^{Exp}	.00849 (.006)	-.00642 (.008)	.00320 (.006)	.00917 (.006)	-.00512 (.007)	.00585 (.006)
Exporter Dummy d_{it}^{Exp}	.225*** (.012)	.297*** (.015)	.146*** (.011)	.216*** (.011)	.304*** (.013)	.138*** (.010)
Importer Dummy d_{it}^{Imp}				.251*** (.009)	.356*** (.012)	.183*** (.009)
Year-Region FE	✓	✓	✓	✓	✓	✓
Sector-Year FE	✓	✓	✓	✓	✓	✓
R^2	.555	.378	.508	.599	.466	.538
Observations	24952	24559	23411	53379	50326	48116

Conclusion

Examined effect of trade on firms via import-quality channel

- Partial equilibrium model with heterogenous inputs and quality complementarity
- Two effects of trade integration in developing country:
  - Substitute imports for high-quality domestic inputs (skilled workers) $\Rightarrow$ skill demand $\downarrow$
  - Complementarity with high-quality imported inputs $\Rightarrow$ skill demand $\uparrow$
- Strong empirical evidence for both effects from Chilean firm panel
- Complementarity effect can help to explain puzzle in trade theory vs. data

Further work

- Derive predicted change in firm-quality distribution when import tariffs fall
- Currently partial equilibrium. Move to GE?

BACKUP

Choice of Input Quality for Given Output Quality $\bar{Q}_\omega$

Cost minimization problem:

$$\min_{q_{i\omega}} \left\{ \int_0^1 c(q_{i\omega})di + m_\omega \quad s.t. \quad A_\omega \left(\int_0^1 \alpha_i q_{i\omega}^{\frac{\rho-1}{\rho}} di \right)^{\frac{\rho}{\rho-1}} \geq \bar{Q}_\omega \right\}$$

Yields optimal input quality $q_{i\omega}$ for given $\bar{Q}_\omega$ and cutoff $\hat{\imath}_\omega$:

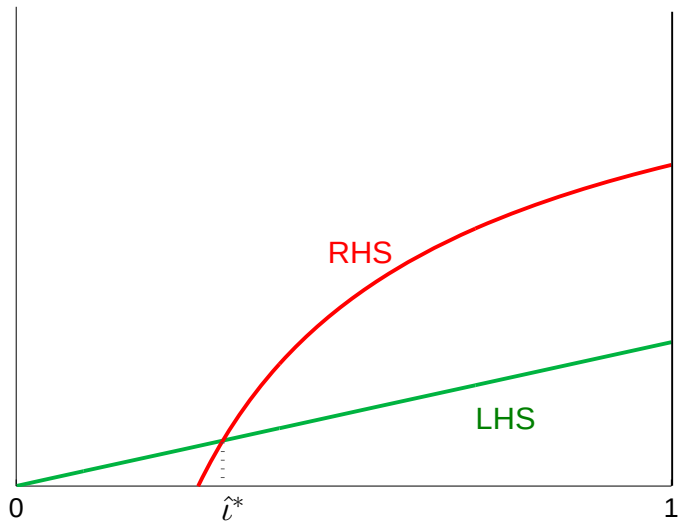
$$q_{i\omega} = \left(\frac{\alpha_i}{c'(q_{i\omega})} \frac{MC_\omega \bar{Q}_\omega}{\int_0^1 \alpha_i q_{i\omega}^{-\frac{1-\rho}{\rho}} di} \right)^\rho$$

Back to talk

Cutoff point for domestic vs. imported inputs $\hat{\iota}_\omega$

Minimize $C(Q_\omega, \hat{\iota}_\omega)/Q_\omega$ with respect Q_ω and $\hat{\iota}_\omega$ yields:

$$2\hat{\iota}_\omega(a_F - a_H) = \frac{3\rho+1}{1+\rho}(a_F + m_\omega) - \frac{1-\rho}{1+\rho} \cdot \frac{a_F - a_H}{\hat{\iota}_\omega^{\frac{2\rho}{1+\rho}} \cdot \left[\left(\frac{b_H}{b_F}\right)^{\frac{1-\rho}{1+\rho}} - 1\right]}$$



Optimal $\hat{\iota}_\omega$ independent of A_ω

Back to talk

Profits and Firm Selection

When producing Q^*_ω, firms earn profits:

$$\Pi(\omega) = (\sigma-1)^{\sigma-1}\sigma^{-\sigma}P^\sigma X \underbrace{\left(\frac{C(Q^*_\omega, \hat{\imath}^*_\omega)}{Q^*_\omega}\right)^{1-\sigma}}_{AC(Q^*_\omega,\hat{\imath}^*_\omega)^{1-\sigma}} - f$$

Suppose:

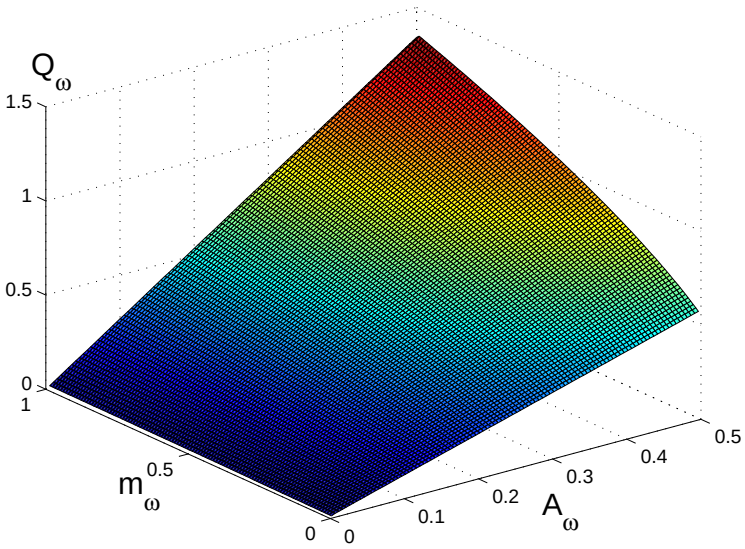
- Currently no access to imports
- 2 entrepreneurs, both have ideas that would currently earn $\Pi(\omega_1) = \Pi(\omega_2) = 0$
- ω_1: high quality, ω_2: low quality
- Decrease import tariffs $\Rightarrow$ ω_1 will enter the market; ω_2 not

$\Rightarrow$ Falling import tariffs favor high-quality producers

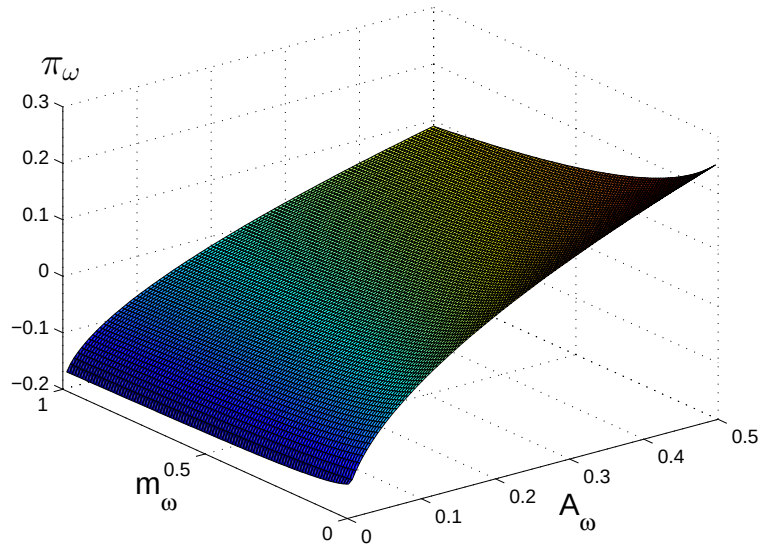
Back to talk

Quality and Profits as Functions of A_ω and m_ω

Output quality



Firm profits



$\Rightarrow$ High-quality producers not necessarily most profitable

▸ Back to talk

Optimal Quality Q^*

$$Q_\omega^* = \frac{\sum_{i=1}^{N} c(q_{i\omega}) + m_\omega + w_U}{\frac{1}{A_\omega}\left(\sum_{i=1}^{N} \alpha_i \left(\frac{c'(q_{i\omega})}{\alpha_i}\right)^{1-\rho}\right)^{\frac{1}{1-\rho}}}$$

- $c(q_{i\omega})$: Cost of task quality
- m_ω: Cost of raw material (per unit of output)
- Unskilled wage rate: w_U
- A_ω: Efficiency of quality production

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Deriving $C(Q_\omega)$ from $c\,(q_{i\omega})$

$$C(Q_\omega) = \sum_{i=1}^{N} \left(a + bq_{i\omega}^2\right) + m_\omega + w_U$$

$$q_{i\omega} = \left(\frac{\alpha_{i\omega} b_{1\omega}}{\alpha_{1\omega} b_{i\omega}}\right)^{\frac{\rho}{1+\rho}} q_{1\omega}$$

$$Q_\omega = A_\omega \left(\frac{b_{1\omega}}{\alpha_{1\omega}}\right)^{\frac{\rho}{\rho+1}} \left(\sum_{i=1}^{N} \alpha_{i\omega} \left(\frac{\alpha_{i\omega}}{b_{i\omega}}\right)^{\frac{\rho-1}{\rho+1}}\right)^{\frac{\rho}{\rho-1}} \cdot q_{1,\omega}$$

$$\Rightarrow\ C(Q_\omega) = C_{f,\omega} + \frac{1}{A_\omega^2} \left(\sum_{i=1}^{N} b_{i\omega}^{\frac{1-\rho}{1+\rho}} \alpha_{i\omega}^{\frac{2\rho}{1+\rho}}\right)^{\frac{1+\rho}{1-\rho}} \cdot Q_\omega^2$$

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Detailed Solution Steps

Optimal input quality $q_{i\omega}$ implicitly determined by:

$$q_{i\omega} = \left(\frac{\alpha_i}{c'\left(q_{i\omega}\right)} \right)^{\rho} \left(\frac{C(Q_\omega)}{\sum_{i=1}^{N} \alpha_i q_{i\omega}^{\frac{\rho-1}{\rho}}} \right)^{\rho}$$

Thus:

$$\frac{q_{i\omega}}{q_{1\omega}} = \left(\frac{\alpha_{i\omega}}{\alpha_{1\omega}} \frac{b_{1\omega} q_{1\omega}}{b_{i\omega} q_{i\omega}} \right)^{\rho} \quad \Rightarrow \quad q_{i\omega} = \left(\frac{\alpha_{i\omega} b_{1\omega}}{\alpha_{1\omega} b_{i\omega}} \right)^{\frac{\rho}{1+\rho}} q_{1\omega}$$

Also:

$$Q_\omega^* = \frac{C(Q_\omega^*)}{MC(Q_\omega^*)} = \frac{\sum_{i=1}^{N} c(q_{i\omega}) + m_\omega + w_U}{\frac{1}{A_\omega} \left(\sum_{i=1}^{N} \alpha_{i\omega}^{\rho} \, c'\left(q_{i\omega}\right)^{1-\rho} \right)^{\frac{1}{1-\rho}}}$$

where:

$$c\left(q_{i\omega}\right) = a_0 + a_2 q_i^2$$

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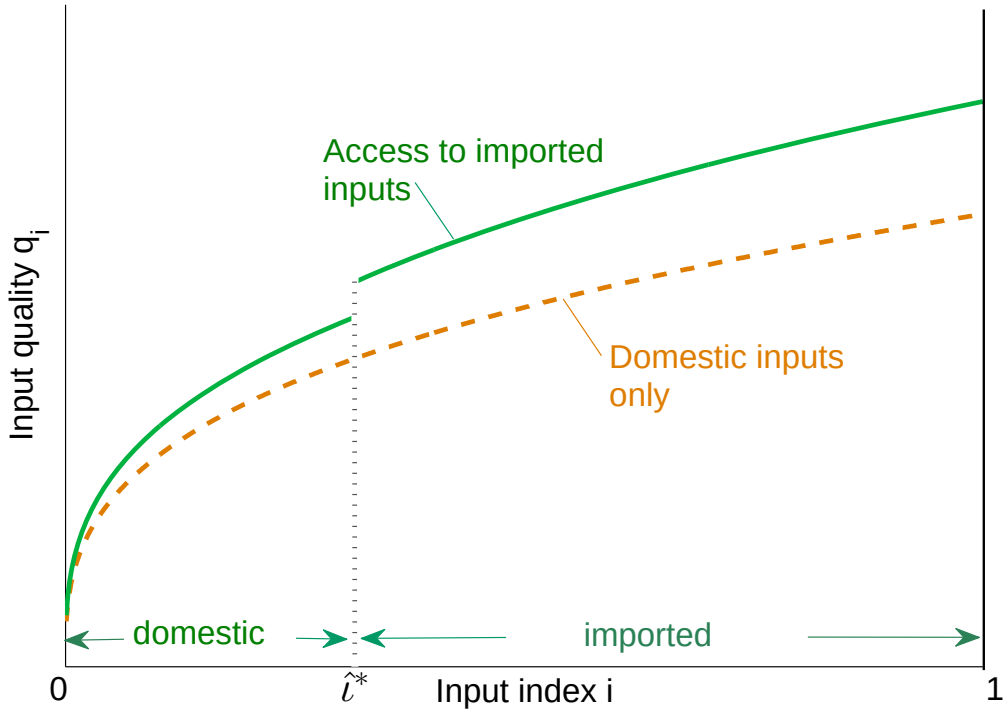
Optimal Input Quality – Graphically

For a firm with given draw a_ω; before and after access to imports



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Deriving $C(Q_\omega)$ from $c\,(q_{i\omega})$

Quadratic functional form $c\,(q_{i\omega})$ given

Use given $\bar{Q}(\omega)$ in:

$$q_{i\omega} = \left(\frac{\alpha_i}{c'\,(q_{i\omega})} \right)^{\rho} \left(\frac{MC(\omega)\,\bar{Q}(\omega)}{\sum_{i=1}^{N} \alpha_i q_{i\omega}^{\frac{\rho-1}{\rho}}} \right)^{\rho}$$

where $MC(Q_\omega) = \frac{1}{A_\omega} \left(\sum_{i=1}^{N} \alpha_i \left(\frac{c'(q_{i\omega})}{\alpha_i} \right)^{1-\rho} \right)^{\frac{1}{1-\rho}}$

Iteration:

1. Initial guess for $\{q_{i\omega}\}_{i=1,\ldots,N}$
2. Solve for $q_{i\omega}\ \forall i$; update $\{q_{i\omega}\}_{i=1,\ldots,N}$ and $MC(\{q_{i\omega}\})$
3. Iterate until $A(\omega) \left(\sum_{i=1}^{N} \alpha_i q_{i\omega}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}} = \bar{Q}(\omega)$
4. Derive $C(Q_\omega) = \sum_{i=1}^{N} c\,(q_{i\omega}) + m_\omega + w_U$

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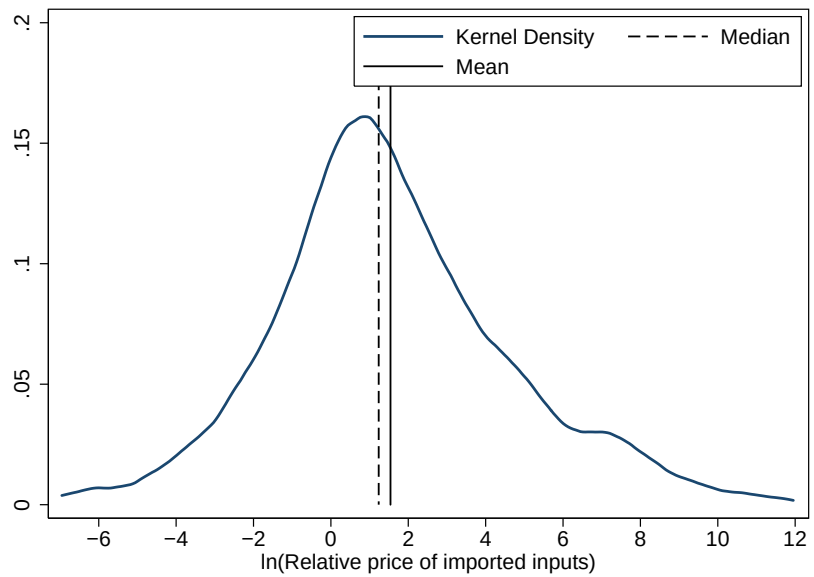
Relative Price of Imports vs. Domestic Inputs

$$\theta_{kt}^{rel} \equiv \ln\left(\frac{\bar{P}_{kt}^{imp}}{\bar{P}_{kt}^{dom}}\right) = \ln\left(\frac{\sum_i V_{ikt}^{imp} / \sum_i Q_{ikt}^{imp}}{\sum_i V_{ikt}^{dom} / \sum_i Q_{ikt}^{dom}}\right)$$

where

- $\bar{P}_{kt}^{dom}$: average price of product k purchased domestically by all firms i
- $\bar{P}_{kt}^{imp}$: average price of product k when imported

Quality of imported inputs as compared to domestic inputs



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The Chilean Data Replicate Prominent Stylized Facts

Table 1: Previous and novel stylized facts.

	(1)	(2)	(3)	(4)	(5)	(6)
	Firm Size		Productivity	——— Skills ———		
Dependent Variable	ln(workers)	ln(Sales)	ln(VA/workers)	White-collar share		ln(wage)
Import dummy	.808***	1.352***	.599***	-.0160***	-.0164***	.308***
	(.019)	(.027)	(.014)	(.004)	(.004)	(.009)
Export dummy	.877***	1.290***	.424***	-.00286	-.00285	.270***
	(.026)	(.035)	(.017)	(.004)	(.004)	(.011)
Import price index					.00922***	.0219***
					(.002)	(.004)
Sector-Year FE	✓	✓	✓	✓	✓	✓
Region dummies	✓	✓	✓	✓	✓	✓
R^2	.46	.54	.40	.13	.13	.56
Observations	63,987	62,063	63,177	63,987	63,987	63,907

Notes: Clustered standard errors (at firm level) in parentheses. Key: *** significant at 1%; ** 5%; * 10%.

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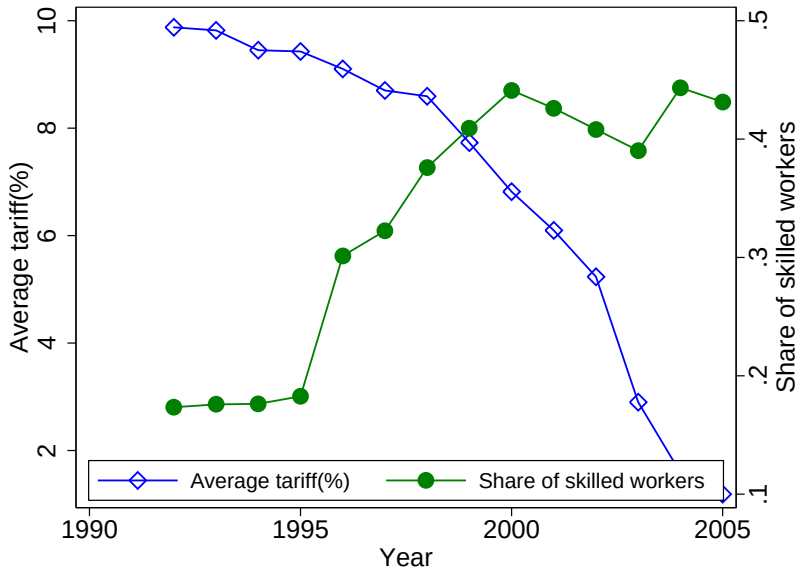
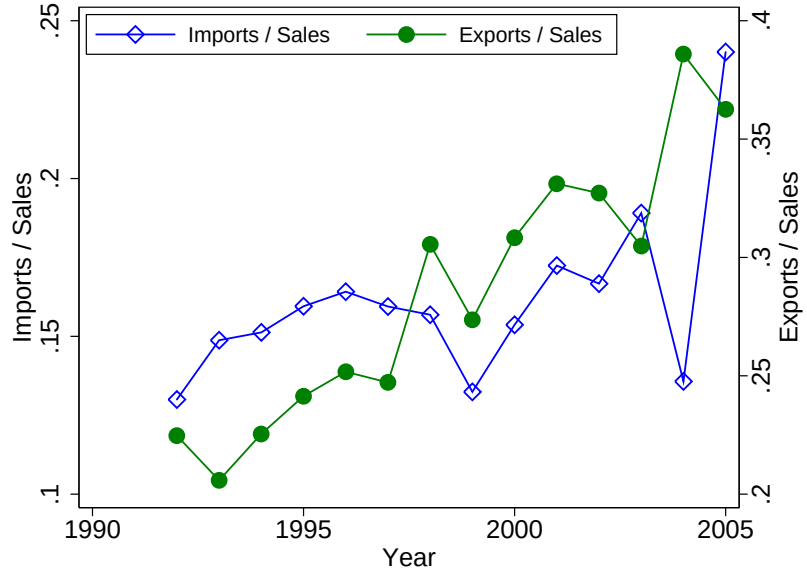
Trade Liberalization in Chile





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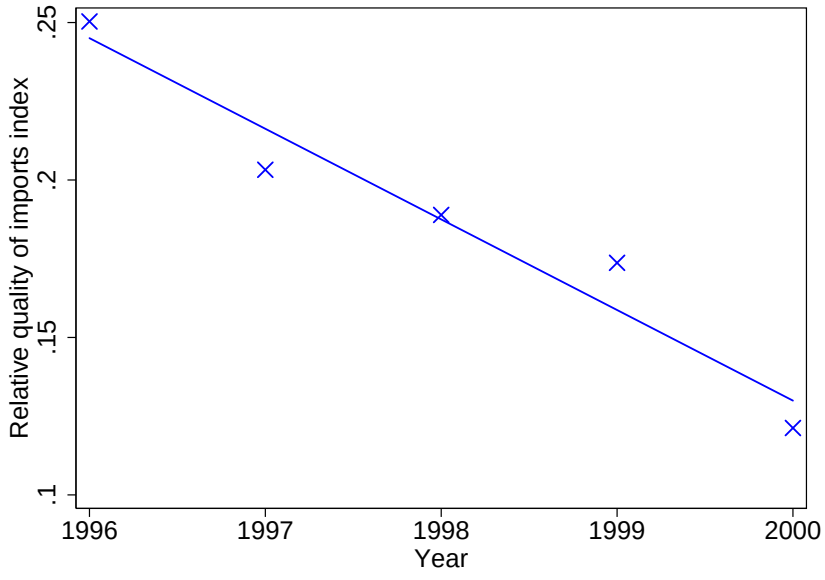
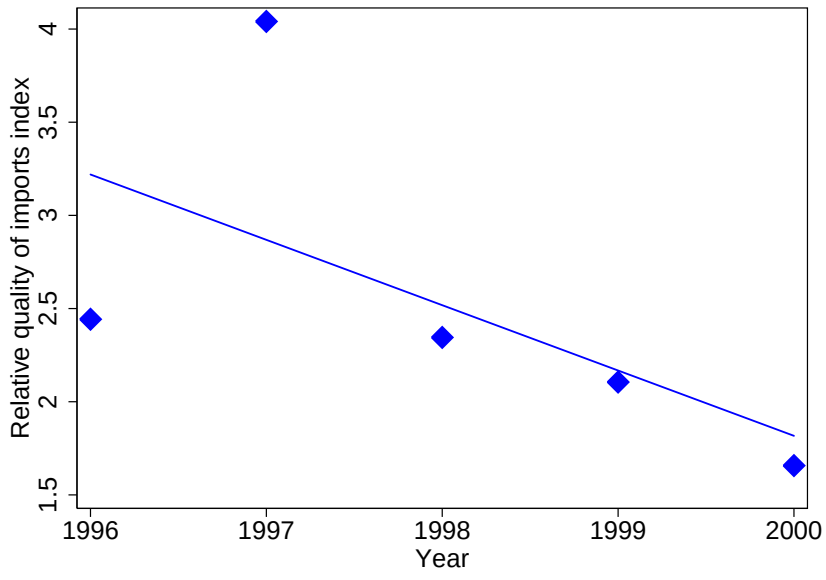
Relative Price of Imports vs. Domestic Inputs

Within-firm variation



Within- and across-firm variation



Left panel: Annual weighted average of the price-based quality index θ_{ikt}^{rel}.
Right panel: Annual average of θ_{kt}. Both measures equal zero if imported and domestically purchased inputs of category k have the same price, on average; the measures are greater than zero if imports of the same good are more expensive.

Demand

Utility

$$U = \left[\int_{\omega \in \Omega} (Q_\omega x_\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right]^{\frac{\sigma}{\sigma-1}}$$

- Q_ω: quality; x_ω: quantity
- $\sigma > 1$: Varieties ω are substitutes

Firms face demand

$$x_\omega = Q_\omega^{\sigma-1} \left(\frac{P}{p_\omega} \right)^{\sigma} X$$

- X: quality-adjusted consumption aggregate
- $P \equiv \left(\int_{\omega \in \Omega} \left(\frac{Q_\omega}{p_\omega} \right)^{\sigma-1} d\omega \right)^{\frac{1}{1-\sigma}}$: aggregate price index
- Focus on individual firms in partial equilibrium $\rightarrow$ X and P given

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Production – Quality

Firms draw technology $\{A_\omega, m_\omega\}$:

- A_ω: productivity term (quality-specific)
- m_ω: quality (=price per unit) of raw material input

Quality production function:

$$Q_\omega = A_\omega \left(\int_0^1 \alpha_i q_{i\omega}^{\frac{\rho-1}{\rho}} di \right)^{\frac{\rho}{\rho-1}}$$

- $i \in [0, 1]$ tasks, each performed at specific quality $q_{i\omega}$
- α_i: sensitivity of output quality wrt quality of input i
- Rank inputs by quality sensitivity: $\boxed{\alpha_i = i}$
- $\rho < 1$: Quality-complementarity across tasks

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Production – Quantity (for given quality)

Inputs needed to produce one unit of final output:

- One unit of *each* input i, purchased at cost $c(q_{i\omega})$
- One unit of raw material of value/quality m_ω (variety-specific, randomly drawn)

Unit cost function:

$$C(\{q_{i\omega}\}) = \int_0^1 c(q_{i\omega})di + m_\omega$$

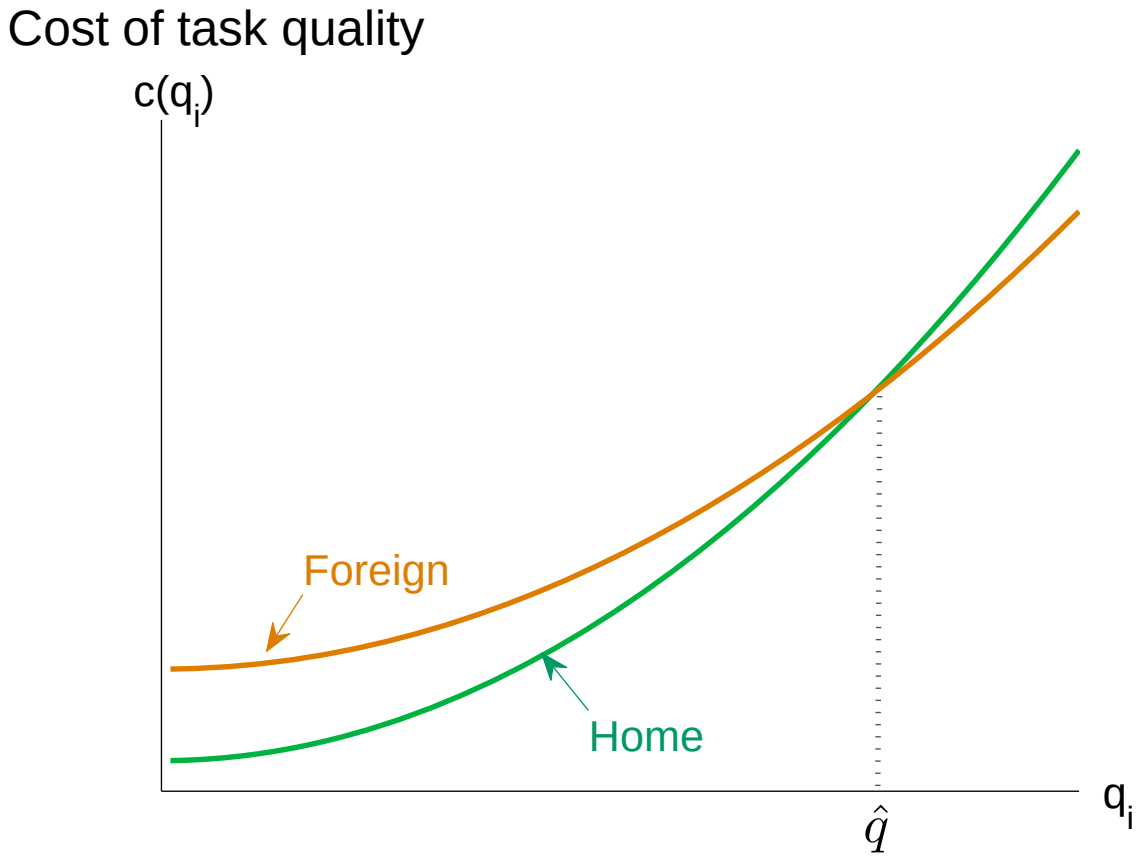
Total cost (x_ω units produced):

$$TC_\omega = C(\{q_{i\omega}\})x_\omega$$

Quality-Specific Input Cost

Cost of Domestic Labor vs. Imported Inputs

- Domestic inputs $c_H(q_{i\omega}) = a_H + b_H q_{i\omega}^2$
- Imported inputs: $c_F(q_{i\omega}) = a_F + b_F q_{i\omega}^2$



Optimization of Production

Profits:

$$\Pi_\omega = [p_\omega - C(Q_\omega)]\, x(Q_\omega) - f$$

- $C(Q_\omega)$: Cost per unit of variety ω at quality Q_ω
- $x(Q_\omega)$: Quantity demanded of ω at quality Q_ω
- f: Fixed cost

Solve model in three steps:

1. Choice of input quality $\{q_{i\omega}\}$ for given output quality $\bar{Q}_\omega$
2. Implied unit cost of given quality $C(\bar{Q}_\omega)$
3. Obtain profit-maximizing choice of output quality Q^*_ω
4. Cutoff point for domestic vs. imported inputs $\hat{\imath}_\omega$

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Unit Cost of Output Quality $C(\bar{Q}_\omega)$

Using optimal input quality $q_{i\omega}$ yields:

$$C(Q_\omega, \hat{\iota}_\omega) = \frac{1}{A_\omega^2} I(\hat{\iota}_\omega)^{\frac{1+\rho}{1-\rho}} \cdot Q_\omega^2 + C_{f,\omega}(\hat{\iota}_\omega)$$

where

$$I(\hat{\iota}_\omega) = \int_0^{\hat{\iota}_\omega} \alpha_i^{\frac{2\rho}{1+\rho}} b_H^{\frac{1-\rho}{1+\rho}} di + \int_{\hat{\iota}_\omega}^1 \alpha_i^{\frac{2\rho}{1+\rho}} b_F^{\frac{1-\rho}{1+\rho}} di; \quad \boxed{I'(\hat{\iota}_\omega) > 0}$$

$$C_{f,\omega}(\hat{\iota}_\omega) = \hat{\iota}_\omega a_H + (1 - \hat{\iota}_\omega) a_F + m_\omega; \quad \boxed{C'_{f,\omega}(\hat{\iota}_\omega) < 0}$$

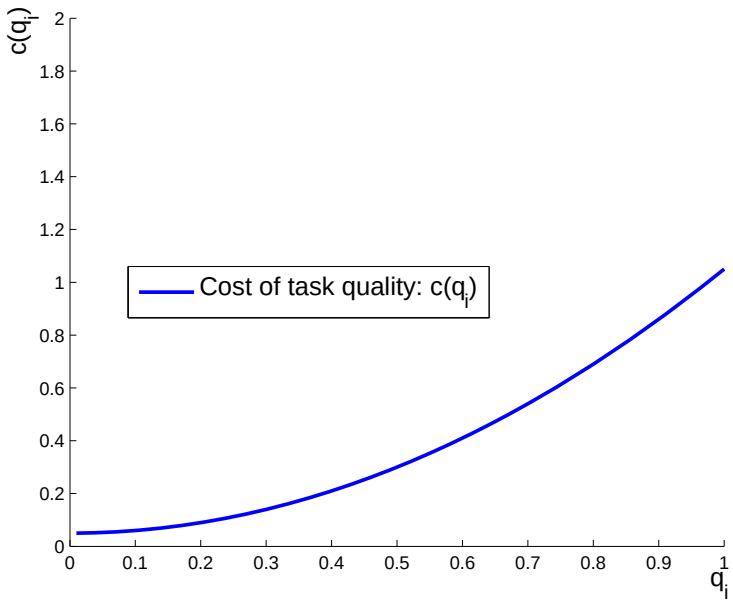
Detail

Input and Output Cost Functions: $c\left(q_{i\omega}\right)$ and $C(Q_{\omega})$

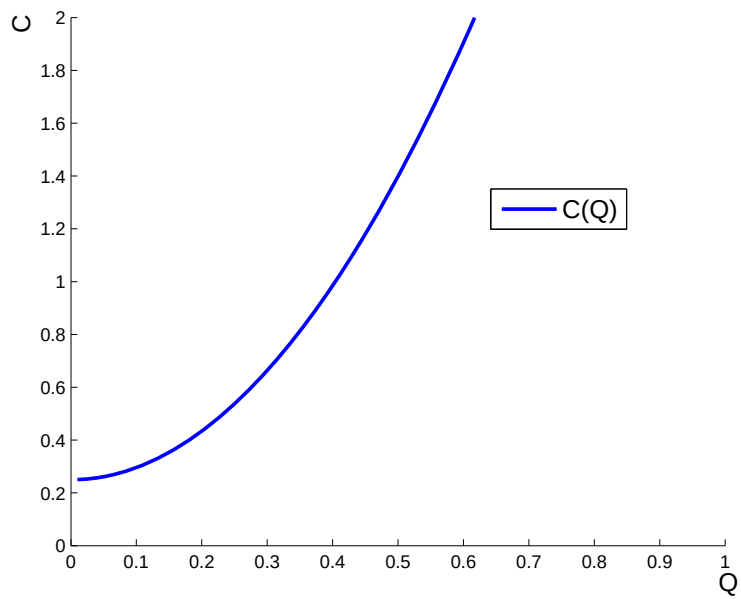
For the simple case of no domestic inputs only ($\hat{\imath}_{\omega} = 1$)

Cost-of-quality profiles:

Cost of input quality $c\left(q_{i\omega}\right)$ (given)



Cost of output quality $C(Q_{\omega})$ (derived)



Profit-Maximizing Choice of Output Quality Q_ω

Pricing:

$$p(\omega) = \frac{\sigma}{\sigma - 1} C(Q_\omega, \hat{\imath}_\omega)$$

Substituting $p(\omega)$ and $x(Q_\omega)$ into the profit equation:

$$\Pi(\omega) = (\sigma - 1)^{\sigma-1} \sigma^{-\sigma} P^\sigma X \underbrace{\left(\frac{C(Q_\omega, \hat{\imath}_\omega)}{Q_\omega} \right)^{1-\sigma}}_{AC(Q_\omega, \hat{\imath}_\omega)^{1-\sigma}} - f$$

Optimal choice of output quality:

minimize $AC \Rightarrow AC = MC$

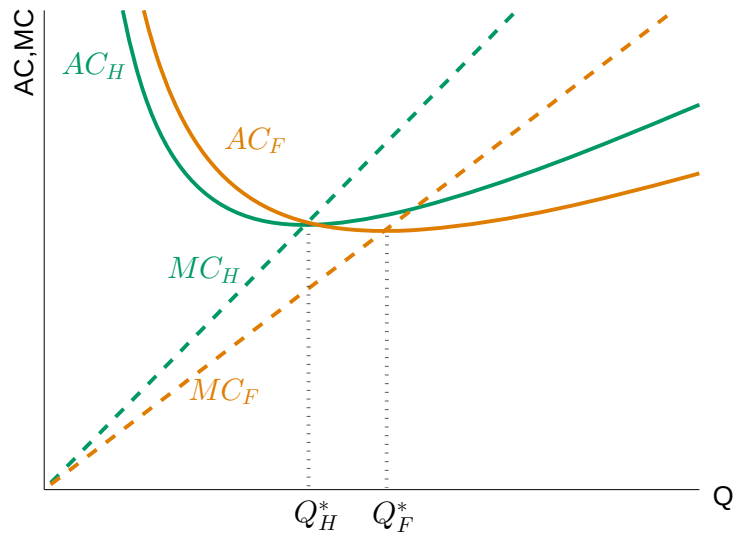
$$\boxed{Q_\omega^* = \frac{C(Q_\omega, \hat{\imath}_\omega)}{MC(Q_\omega, \hat{\imath}_\omega)}}$$

▸ Detail

Simple case without imported inputs in home/foreign

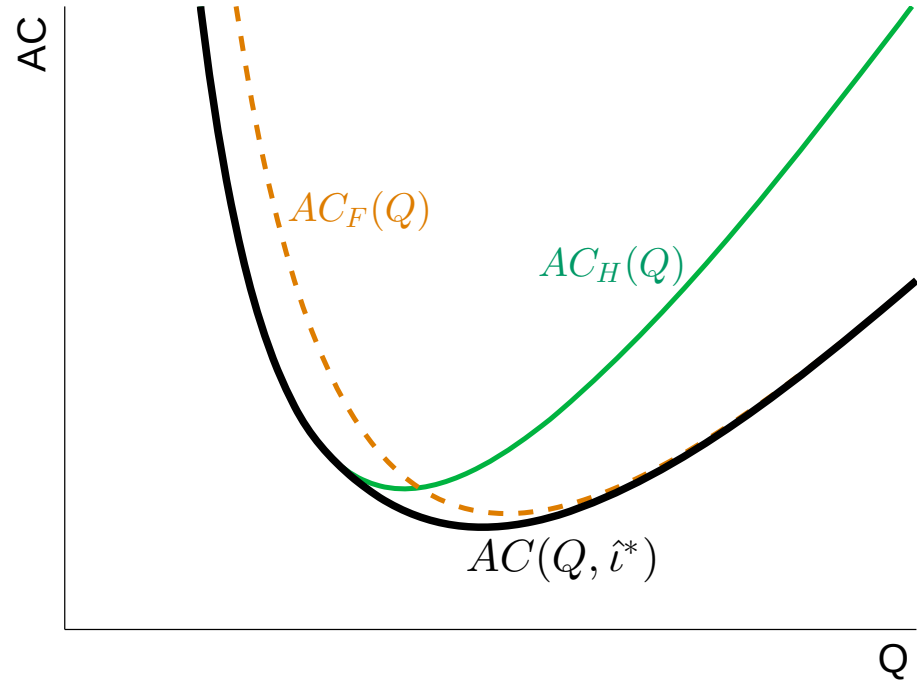
$$Q^*_\omega = \frac{C(Q^*_\omega)}{MC(Q^*_\omega)} \Leftrightarrow MC(Q^*_\omega) = AC(Q^*_\omega)$$

Optimal variety quality with domestic and foreign input prices



- Higher output quality in foreign
- Due to flatter foreign input-cost profile

Average cost of output quality for optimal choice of import cutoff $\hat{\iota}_\omega$



High-quality producers gain most from access to imported inputs

▸ Derivation $\hat{\iota}_\omega$ ▸ Profits and Firm Selection

Result 1: Optimal Variety Quality

$$Q^*_\omega = A_\omega \sqrt{\frac{C_{f,\omega}(\hat{\iota}^*_\omega)}{I(\hat{\iota}^*_\omega)^{\frac{1+\rho}{1-\rho}}}}$$

where $C'_{f,\omega}(\hat{\iota}_\omega) < 0$ and $I'(\hat{\iota}_\omega) > 0$

Predictions:

- Firms that import relatively more inputs (lower cutoff $\hat{\iota}_\omega$) produce higher-quality output
- Thus: Importers produce higher-quality output than non-importers

Result 2: Quality of Domestic Inputs

$$\boxed{q^*_{i\omega} = \left(\frac{i}{b_H}\right)^{\frac{\rho}{1+\rho}} \sqrt{\frac{C_{f,\omega}(\hat{\imath}^*_\omega)}{I(\hat{\imath}^*_\omega)}}}$$

defined for inputs $i \leq \hat{\imath}^*_\omega$

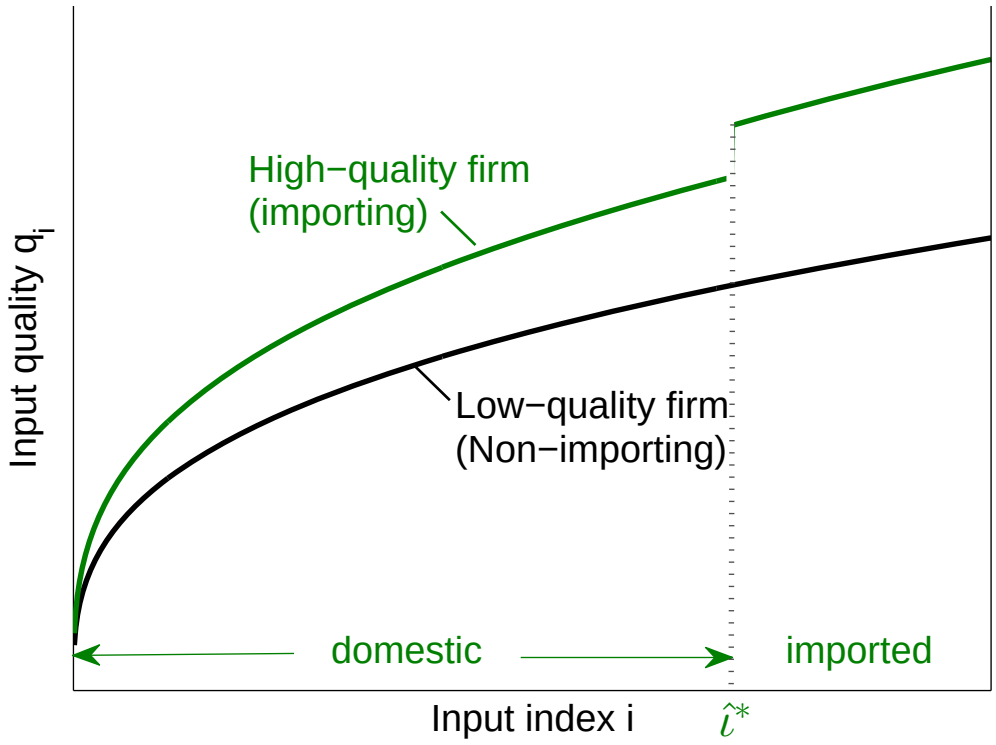
recall: $C'_{f,\omega}(\hat{\imath}_\omega) < 0$ and $I'(\hat{\imath}_\omega) > 0$. Also: $\alpha_i = i$: quality sensitivity

Predictions:

- (Substitution effect): Importers purchase relatively fewer high-quality inputs domestically $\Rightarrow$ demand for input quality (skills) $\downarrow$
- (Complementarity effect): For a given input i, importing firms use higher-quality domestic inputs than non-importers $\Rightarrow$ demand for input quality (skills) $\uparrow$
  - More imports: $\hat{\imath}^*_\omega \downarrow \Rightarrow C_{f,\omega}(\hat{\imath}_\omega) \uparrow, I(\hat{\imath}^*_\omega) \downarrow \Rightarrow q^*_{i\omega} \uparrow$

Optimal Input Quality – Graphically

For a high-quality firm (a_ω high) and a low-quality firm (a_ω small)



▸ Within Firm

Mapping the Model to the Data

Three possibilities to perform task/input i:

1. Import task in the form of a physical input
   - observed at the detailed product level
2. Purchase physical input domestically
   - observed at the detailed product level
3. Hire domestic labor to perform the task
   - observe two main categories: blue-collar vs. white-collar workers
   - need to calculate *average* input quality (wages) for the two subsets

Average Input Quality

- Define the average input quality (skill level) of firm ω:

$$S_\omega = \frac{1}{\hat{\iota}^*_\omega} \int_0^{\hat{\iota}^*_\omega} q^*_{i\omega} di = \xi \cdot \left(\frac{\hat{\iota}^*_\omega}{b_H} \right)^{\frac{\rho}{1+\rho}} \cdot \sqrt{\frac{C_{f,\omega}(\hat{\iota}^*_\omega)}{I(\hat{\iota}^*_\omega)}}$$

$\xi \equiv (\rho + 1)/(2\rho + 1)$. Recall: $C'_{f,\omega}(\hat{\iota}_\omega) < 0$ and $I'(\hat{\iota}_\omega) > 0$

More imported inputs: $\hat{\iota}^*_\omega$ smaller:

1. Skill substitution effect: High-quality imports substitute for skilled domestic labor $\Rightarrow$ $S_\omega \downarrow$
2. Complementarity effect: $\sqrt{\cdot}$ term increases $\Rightarrow$ $S_\omega \uparrow$

Strong complementarity ($\rho \to 0$): 2. effect dominates

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Skilled Labor Share vs. Wages

Blue and White Collar Workers

- Assume that white collar workers typically perform more quality-sensitive tasks $\Rightarrow$ high i tasks performed by white-collar workers
- i represents the extensive margin (worker categories)
- Imports replace white-collar workers (expect neg. corr. b/w imports and white-collar share) – when not controlling for import quality

Wages

- Assume that wages reflect the "quality" of workers within each category
- q_i represents the intensive margin (wages within given worker category)
- Corr. b/w imports and wages can be positive or negative, depending on how strong the complementarity effect is

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Import Quality Indicator I: Import Price Index

1. Relative price of import k purchased by firm i:

$$\theta_{ik} = \sum_{j=1}^{J} \omega_{ikj} \ln\left(\frac{P_{ikj}}{\bar{P}_{kj}}\right), \quad \text{where} \quad \omega_{ikj} \equiv \frac{V_{ikj}}{\hat{V}_{ik}}$$

where

- θ_{ik}: index for the quality (as proxied by prices) of import k used by firm i, relative to the quality of k used by all other firms in the sample
- $\bar{P}_{kj}$: weighted average price of imports in HS-8 category k that are measured in unit j
- $\hat{V}_{ik} = \sum_{j=1}^{J} V_{ikj}$: total value of firm i's imports of product category k (comprising all units of measurement j)

2. Relative price of all imports purchased by firm i:

$$\theta_i = \sum_{k=1}^{K} \frac{\hat{V}_{ik}}{\hat{V}_i} \theta_{ik}$$

Imports vs. Domestic Inputs Back to talk

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▸ Imports vs. Domestic Inputs ▸ Back to talk

Import Quality Indicator II: Import Skill Intensity

$$\sigma_{it} = \sum_{j=1}^{N} s_{ijt} h_{jt}^{w}$$

Where

- N: number of import categories (HS-6)
- s_{ijt}: share of import j in overall imports by firm i in year t
- h_{jt}^{w}: white-collar wage bill share in the production of product j in the U.S. in year t. Matched to U.S. SIC-4

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