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# Quality upgrading and position in global value chains

Kossi-Messanh Agbekponou, Angela Cheptea, Karine Latouche



**IATRC Meeting**

11 December 2022

Clearwater Beach, FL and on-line

- **Product quality** plays an important role in explaining **international trade patterns**:
  - Higher income countries and more productive firms export higher quality goods (Schott, 2004; Hummels and Klenow, 2005; Baldwin and Harrigan, 2011; Fajgelbaum et al., 2011)
  - Quality upgrading permits firms to increase their export performance (Crozet et al. 2012)
- **GVCs** have transformed international trade
  - Production processes are highly fragmented across country borders
  - An increasing number of firms organize production on a global scale
  - A higher content of imported inputs in exports and of services in manufacturing  
≈ 45% of global trade in agricultural and food products goes to intermediate consumption
  - A **reorganization** (reshoring, regionalization, digitalization) of **GVCs** after **Covid-19**?
- **How firms position in GVCs**?
  - Upper and lower ends of the value chain provide higher value added and profit margins (the *smile curve*: Rungi and del Prete, 2018; Mahy et al., 2021)
  - More productive firms internalize a larger span of production stages (Chor et al., 2021)  
⇒ Chinese firms have increased their participation in GVCs by integrating more upstream stages.
- **How quality** affects firms' participation and **position in GVCs**?

**Question:** How firms that differ in terms of product quality position in GVCs?

**Approach:** Extend the CMY framework to include firms' decision on product quality.

Chor, Manova and Yu (2021):

Heterogeneous firms maximize profits by choosing the processing level and quantity of goods they produce and of inputs they buy.

- + Consumers are willing to pay higher prices for higher-quality goods.
- + Producing higher-quality goods is harder and costlier.
- + Firms choose the quality level of produced goods.

**Empirics:** Data on French agri-food firms, 2000-2018.

**Result:** Quality upgrading determines firms to internalize more production stages.

**H1: Participation to GVCs** = firm's **joint** involvement in **import and export** activities  
(Baldwin and Yan, 2014; Antras, 2020)

⇒ We focus on firms in GVCs, i.e. that both import and export in a given year.

**H2: Firms' imports and exports** reflect their **purchases and outputs** in terms of  
product composition

⇒ Imports (from all sources) ~ firm's input purchases

⇒ Exports (to all destinations) ~ firm's sales of produced output

**H3: Position in the chain** = the **level of transformation (processing)** of goods  
used and produced by the firm.

(Fally, 2012; Antras et al., 2012; Alfaro et al., 2019)

⇒ A highly disaggregated I-O table to identify the level of transformation of each industry  
Apply the same level to all products within an industry.

**H4: More upstream products** are traded at **lower prices**

- Consumers value quality ( $\lambda$ ) and maximize a CES utility function over available varieties  $\Omega_v$ :

$$\Upsilon = \left( \int_{\Omega_v} [\lambda(v)q(v)]^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

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- Production of each variety  $v$  requires the completion of a continuum of tasks  $u$ , indexed by their remoteness from final demand (upstreamness), using a CES aggregator:

$$q = \theta \left( \int_{U^X}^{U^M} x(u)^{\frac{\sigma-1}{\sigma}} du + q_M^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\rho\sigma}{\sigma-1}}$$

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Producing higher-quality goods is harder ( $0 \leq \gamma < 1$ ) and incurs fixed costs  $\lambda^\alpha$ .



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Producing higher-quality goods is harder ( $0 \leq \gamma < 1$ ) and incurs fixed costs  $\lambda^\alpha$ .

- **Firms** choose the quantity ( $q_M$ ,  $x(u)$ ) and processing level ( $U^M$ ,  $U^X$ ) of inputs they purchase and produce in-house, and the quality of output ( $\lambda$ ) that **maximize** their **profits**:

$$\pi = pq - \left( p_M q_M + \int_{U^X}^{U^M} [c(u)x(u) + F(u)] du + \lambda^\alpha \right)$$

Under reasonable assumptions:

- mild decreasing returns to scale ( $\rho > \frac{\sigma-1}{\sigma}$ )
- relatively small variable & fixed costs of in-house produced inputs  $\left( \frac{c(u) \times (u)}{P_M q_M}, \frac{F_M}{P_M q_M} \right)$

Quality upgrading ( $\lambda > 0$ ) leads to:

- 1 the purchase of more upstream inputs  $\left( \frac{dU^M}{d\lambda} > 0 \right)$   
 the production of more downstream goods  $\left( \frac{dU^X}{d\lambda} < 0 \right)$   
 $\Rightarrow$  larger span of production stages performed by the firm  $\left( \frac{d(U^M - U^X)}{d\lambda} > 0 \right)$
- 2 an increase in variable & fixed costs, input purchases, and value added;  
 a negligible effect on profits.

## Data on French agri-food firms: 2000–2018

AMADEUS	turnover, size (# employees), ... , economic activity (NACE)
French customs	product-level bilateral imports and exports
Sample	3,562 importing firms 4,714 exporting firms 2,582 firms in GVCs (import & export)

## US input-output table (BEA)

- + US/French industry correspondences
- + for multiple correspondences, assume equal weights for all industry pairs
- ⇒ an input-output table at the level of French industries

405 US industries (42 agrifood) → 604 NACE industries (88 agrifood)

NACE I-O table

- Compute the **upstreamness** of each **industry**  $r$  as a weighted average of the number of production stages from final demand for which it provides inputs (Fally, 2012; Antràs et al., 2012; Antràs and Chor, 2013):

$$U_r = 1 \cdot \frac{F_r}{Y_r} + 2 \cdot \frac{\sum_s b_{rs} F_s}{Y_r} + 3 \cdot \frac{\sum_s \sum_k b_{rk} b_{ks} F_s}{Y_r} + 4 \cdot \frac{\sum_s \sum_k \sum_l b_{rl} b_{lk} b_{ks} F_s}{Y_r} + \dots$$

(weights = shares of provided inputs in industry's output)

	Frequency	Min	Max	Mean	Std. dev.
Upstreamness - all industries	604	1.00	4.51	1.88	0.75
Upstreamness - agrifood	88	1.08	3.61	1.85	0.72

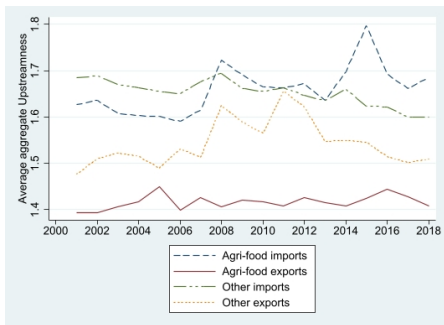
NACE industry	Upstreamness
Retail sale of fruit and vegetables in specialised stores	1.01
Retail sale of meat and meat products in specialised stores	1.01
Retail sale of bread, cakes, flour confectionery and sugar confectionery in specialised stores	1.01
Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes	1.08
Manufacture of bread; manufacture of fresh pastry goods and cakes	1.10
Manufacture of prepared meals and dishes	1.20
Manufacture of wine from grape	1.23
Growing of vegetables and melons, roots and tubers	1.28
Manufacture of cocoa, chocolate and sugar confectionery	1.39
Processing and preserving of meat	1.44
Growing of pome fruits and stone fruits	1.46
Processing of tea and coffee	1.47
Manufacture of fruit and vegetable juice	1.47
Processing and preserving of fish, crustaceans and molluscs	1.60
Marine fishing	1.66
Raising of swine/pigs	2.10
Manufacture of starches and starch products	2.16
Manufacture of oils and fats	2.72
Raising of dairy cattle	2.98
Growing of cereals (except rice), leguminous crops and oil seeds	3.45
Seed processing for propagation	3.61

- Use the product composition of trade to compute the **upstreamness** for each firm  $f$ :

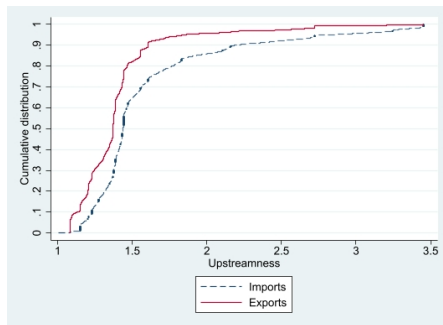
Upstreamness of exports:  $U_f^X = \sum_r \frac{X_{fr}}{X_f} U_r$

Upstreamness of imports:  $U_f^M = \sum_r \frac{M_{fr}}{M_f} U_r$

Involvement in GVCs:  $GVC_f = U_f^M - U_f^X$  (span of in-house production stages)



(a) Average import and export upstreamness



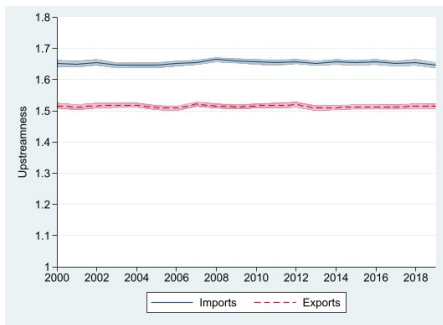
(b) Cumulative distribution of French firms

- Use the product composition of trade to compute the **upstreamness** for each firm  $f$ :

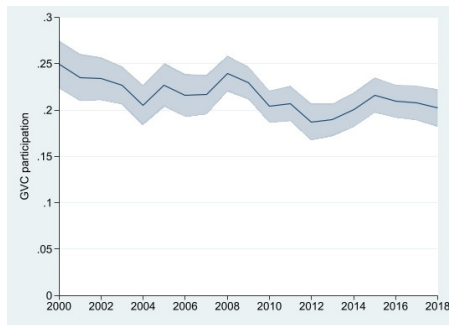
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Involvement in GVCs:  $GVC_f = U_f^M - U_f^X$  (span of in-house production stages)



(a) Import and export upstreamness ( $U^M$  and  $U^X$ )



(b) Involvement in GVC ( $U^M - U^X$ )

# Decomposition of sector-level *upstreamness*

$$\Delta U_t^M = \sum_{f \in \Xi_t^M} \frac{M_{ft}}{M_t} \cdot U_{ft}^M - \sum_{f \in \Psi_t^M} \frac{M_{f,t-1}}{M_{t-1}} \cdot U_{f,t-1}^M + \sum_{f \in \Gamma_t^M} \frac{M_{f,t-1}}{M_{t-1}} \cdot \Delta U_{ft}^M + \sum_{f \in \Gamma_t^M} \Delta \frac{M_{ft}}{M_t} \cdot U_{ft}^M$$

$$\Delta U_t^X = \underbrace{\sum_{f \in \Xi_t^X} \frac{X_{ft}}{X_t} \cdot U_{ft}^X}_{\text{starting firms}} - \underbrace{\sum_{f \in \Psi_t^X} \frac{X_{f,t-1}}{X_{t-1}} \cdot U_{f,t-1}^X}_{\text{stopping firms}} + \underbrace{\sum_{f \in \Gamma_t^X} \frac{X_{f,t-1}}{X_{t-1}} \cdot \Delta U_{ft}^X}_{\Delta \text{upstreamness}} + \underbrace{\sum_{f \in \Gamma_t^X} \Delta \frac{X_{ft}}{X_t} \cdot U_{ft}^X}_{\Delta \text{mkt share}}$$

extensive margin
intensive margin

	Extensive margin			Intensive margin (incumbent)			Overall
	Starting firms	Stopping firms	Net effect	change in firm's upstreamness	change in firm's mkt share	Net effect	
$\Delta U_t^M$	0.1329	-0.0336	0.0993	0.0064	0.0559	0.0623	0.1616
$\Delta U_t^X$	0.1846	-0.1074	0.0772	-0.0032	0.1029	0.0998	0.1770
$\Delta U_t^M - \Delta U_t^X$	-0.0517	0.0738	0.0221	0.0096	-0.0470	-0.0374	-0.0154

⇒ Annual changes in sector-level upstreamness explained mainly by the extensive margin (firms that start/stop exporting/importing) and changes in firms' market shares.

⇒ Small changes in firms' upstreamness.



- Compute **quality at firm-product-market level** as the residual extra quantity for a given price (Khandelwal et al., 2013):

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = \text{Controls (FE)} + e_{fjkt}$$

and price elasticities  $\varepsilon_k$  estimated by Fontagné et al. (2022) at the HS 4-digit level.

⇒ relative **quality** of the firm in a specific **product-destination** market:  $\ln \hat{\lambda}_{fjkt} = \frac{\hat{e}_{fjkt}}{\varepsilon_k - 1}$

- Retrieve **firm-specific quality**:

– Estimate price-adjusted quantities with **firm-year FE** and country-product FE:

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = FE_{ft} + FE_{jkt} + e_{fjkt}$$

– Standardize estimated firm FE:  $\hat{Q}_{ft} = \frac{\widehat{FE}_{ft} - \overline{\widehat{FE}_{ft}}}{SE[\widehat{FE}_{ft}]}$

+ 3 alternative ways to obtain firm quality

quality

- Compute **quality at firm-product-market level** as the residual extra quantity for a given price (Khandelwal et al., 2013):

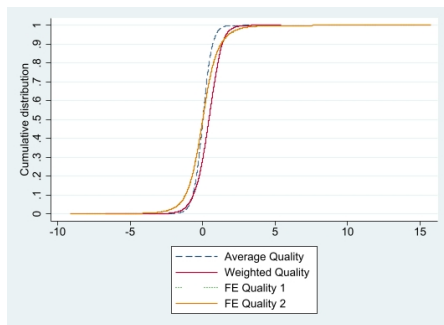
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⇒ relative **quality** of the firm in a specific **product-destination** market:  $\ln \hat{\lambda}_{fjkt} = \frac{\hat{e}_{fjkt}}{\varepsilon_k - 1}$

- Four measures of **firm quality**:

	$\widehat{Q}_{ft}$	$\widehat{Q1}_{ft}$	$\widehat{Q2}_{ft}$	$\widehat{Q3}_{ft}$
$\widehat{Q}_{ft}$	1			
$\widehat{Q1}_{ft}$	0.8543	1		
$\widehat{Q2}_{ft}$	0.6383	0.7829	1	
$\widehat{Q3}_{ft}$	0.9695	0.8397	0.6267	1



## Test the model predictions

	Imports upstreamness ( $U_{ft}^M$ )	Exports upstreamness ( $U_{ft}^X$ )	Involvement in GVCs ( $GVC_{ft}$ )	Imports upstreamness ( $U_{ft}^M$ )	Exports upstreamness ( $U_{ft}^X$ )	Involvement in GVCs ( $GVC_{ft}$ )
Quality				0.0171** (0.0067)	-0.0098* (0.0052)	0.0270*** (0.0085)
In Productivity	-0.0022 (0.0159)	0.0031 (0.0101)	-0.0053 (0.0185)	-0.0031 (0.0194)	0.0112 (0.0119)	-0.0143 (0.0219)
Firm size						
small	reference	reference	reference	reference	reference	reference
medium	0.0353 (0.0274)	0.0053 (0.0166)	0.0300 (0.0326)	0.0502 (0.0339)	0.0138 (0.0174)	0.0364 (0.0378)
large	0.0395 (0.0526)	0.0276 (0.0221)	0.0120 (0.0561)	0.0691 (0.0636)	0.0318 (0.0252)	0.0374 (0.0687)
Fixed effects	firm, industry-year			firm, industry-year		
Observations	6,383	6,383	6,383	5,069	5,069	5,069
$R^2$	0.829	0.831	0.764	0.842	0.858	0.793

- ⇒ Non significant effect of productivity on firms' upstreamness and involvement in GVCs.
- ⇒ Higher-quality firms import more upstream inputs and export more downstream products. perform a larger span of in-house production stages.
- ⇒ Similar results with the four quality measures and additional controls.

⇒ IV estimates: instrument quality by the change in foreign demand for firms' products.

	First stage	Second stage		
	Quality	$U_{ft}^M$	$U_{ft}^X$	$GVC_{ft}$
Instrument	0.0309*** (0.0092)			
Quality		0.2038* (0.1120)	-0.1761** (0.0731)	0.3799*** (0.1293)
In Productivity	0.0360 (0.0422)	-0.0088 (0.0215)	0.0203 (0.0144)	-0.0291 (0.0248)
Firm size				
small	reference	reference	reference	reference
medium	-0.0196 (0.0705)	0.0468 (0.0332)	0.0141 (0.0185)	0.0327 (0.0370)
large	-0.1779 (0.1364)	0.0956 (0.0673)	0.0024 (0.0269)	0.0932 (0.0714)
Fixed effects	firm, industry-year	firm, industry-year		
Observations	4,845	4,845	4,845	4,845
$R^2$	0.721	0.847	0.862	0.799
F-stat	11.3938			
Endogeneity test		2.901*	5.519**	7.673**
$p$ -value		(0.0885)	(0.0188)	(0.0056)

- Firm quality and productivity
  - Firm's quality is weakly correlated to productivity ( $< 0.10$ ).
  - Productivity positively affects quality

	Quality $\hat{Q}_{ft}$	Average quality	Weighted quality	FE quality
In Productivity	0.0775** (0.0304)	0.0433** (0.0192)	0.0590*** (0.0221)	0.0681** (0.0299)
Firm size:				
small	reference	reference	reference	reference
middle	0.0451 (0.0554)	0.0265 (0.0323)	0.0993** (0.0431)	0.0334 (0.0558)
large	-0.0487 (0.1194)	0.0136 (0.0662)	0.1520* (0.0874)	-0.0950 (0.1096)
Fixed effects		firm, industry-year		
Observations	8,737	8,785	11,039	8,737
$R^2$	0.727	0.697	0.700	0.746

- Test the model prediction on firms' costs, value added, profits

	Raw Input Costs	Wagebill	Total Assets	Pofits	Value Added
Involvement in GVC	0.0108 (0.0182)	-0.0112 (0.0142)	-0.0054 (0.0160)	0.0224 (0.0448)	-0.0176 (0.0195)
Fixed effects			firm, industry-year		
Observations	9,629	9,646	9,782	7,669	9,274
$R^2$	0.961	0.975	0.977	0.851	0.961

⇒ Similar results with additional controls.

- Test the model prediction on firms' costs, value added, profits

	Raw Input Costs	Wagebill	Total Assets	Pofits	Value Added
Import upstreamenss	0.0178 (0.0237)	-0.0047 (0.0187)	-0.0078 (0.0194)	0.0401 (0.0554)	-0.0046 (0.0262)
Export upstreamenss	0.0059 (0.0415)	0.0269 (0.0285)	-0.0005 (0.0323)	0.0167 (0.0742)	0.0484* (0.0260)
Fixed effects			firm, industry-year		
Observations	9,629	9,646	9,782	7,669	9,274
$R^2$	0.961	0.975	0.977	0.851	0.961

⇒ Similar results with additional controls.

Question: How product quality affects firms' position in GVCs?

Approach and results:

- Extend Chor, Manova and Yu (2021) to include firms' decision on product quality:
  - ★ Quality upgrading  $\Rightarrow$  a larger span of in-house production stages and  
 $\Rightarrow$  an increase in firms' costs and value-added
- Prediction on GVC position confirmed by data on French agri-food firms
- Similar results with different quality measures
- Controlling for reverse causality yields a stronger effect
- No effect of GVC position on firms' costs, value added, and profits

To do list:

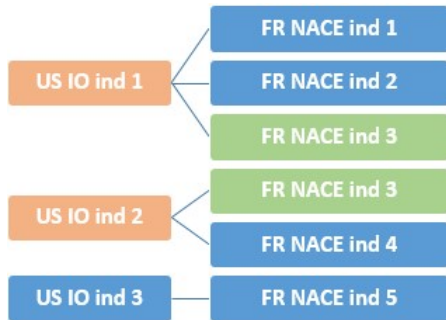
- Control for reverse causality between productivity and position in GVCs
- Alternative ways to measure firm productivity
- Explain the absence of an effect of GVC position on firms' costs and value added
- Check model predictions with a Cobb-Douglas production function



# Build a detailed input-output table for France

		Used inputs and value added			Final use	Total use
		US IO ind 1	US IO ind 2	US IO ind 3		
Supply of intermediate inputs	US IO ind 1	$a_{11}$	$a_{12}$	$a_{13}$	$F_1$	$Y_1$
	US IO ind 2	$a_{21}$	$a_{22}$	$a_{23}$	$F_2$	$Y_2$
	US IO ind 3	$a_{31}$	$a_{32}$	$a_{33}$	$F_3$	$Y_3$
Value added		$VA_1$	$VA_2$	$VA_3$		
Total output		$Y_1$	$Y_2$	$Y_3$		

(a) US input-output table



(b) Multiple industry correspondences

Figure: US input-output table structure and correspondences with NACE Rev.2

# Build a detailed input-output table for France

		US IO ind 1			US IO ind 2		US IO ind 3
		FR NACE ind 1	FR NACE ind 2	FR NACE ind 3	FR NACE ind 3	FR NACE ind 4	FR NACE ind 5
US IO ind 1	FR NACE ind 1	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{6} a_{12}$	$\frac{1}{6} a_{12}$	$\frac{1}{3} a_{13}$
	FR NACE ind 2	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{6} a_{12}$	$\frac{1}{6} a_{12}$	$\frac{1}{3} a_{13}$
	FR NACE ind 3	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{6} a_{12}$	$\frac{1}{6} a_{12}$	$\frac{1}{3} a_{13}$
US IO ind 2	FR NACE ind 3	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{4} a_{22}$	$\frac{1}{4} a_{22}$	$\frac{1}{2} a_{13}$
	FR NACE ind 4	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{4} a_{22}$	$\frac{1}{4} a_{22}$	$\frac{1}{2} a_{13}$
US IO ind 3	FR NACE ind 5	$\frac{1}{3} a_{31}$	$\frac{1}{3} a_{31}$	$\frac{1}{3} a_{31}$	$\frac{1}{2} a_{21}$	$\frac{1}{2} a_{21}$	$a_{33}$

Figure: Equal weights for all correspondences within each pair of industry codes

# Build a detailed input-output table for France

	FR NACE ind 1	FR NACE ind 2	FR NACE ind 3	FR NACE ind 4	FR NACE ind 5
FR NACE ind 1	$b_{11} = \frac{1}{9} a_{11}$	$b_{12} = \frac{1}{9} a_{11}$	$b_{13} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12}$	$b_{14} = \frac{1}{6} a_{12}$	$b_{15} = \frac{1}{3} a_{13}$
FR NACE ind 2	$b_{21} = \frac{1}{9} a_{11}$	$b_{22} = \frac{1}{9} a_{11}$	$b_{23} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12}$	$b_{24} = \frac{1}{6} a_{12}$	$b_{25} = \frac{1}{3} a_{13}$
FR NACE ind 3	$b_{31} = \frac{1}{9} a_{11} + \frac{1}{6} a_{21}$	$b_{32} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12}$	$b_{33} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12} + \frac{1}{6} a_{21} + \frac{1}{4} a_{22}$	$b_{34} = \frac{1}{6} a_{12} + \frac{1}{4} a_{22}$	$b_{35} = \frac{1}{3} a_{13} + \frac{1}{2} a_{13}$
FR NACE ind 4	$b_{41} = \frac{1}{6} a_{21}$	$b_{42} = \frac{1}{6} a_{21}$	$b_{43} = \frac{1}{6} a_{21} + \frac{1}{4} a_{22}$	$b_{44} = \frac{1}{4} a_{22}$	$b_{45} = \frac{1}{2} a_{13}$
FR NACE ind 5	$b_{51} = \frac{1}{3} a_{31}$	$b_{52} = \frac{1}{3} a_{31}$	$b_{53} = \frac{1}{3} a_{31} + \frac{1}{2} a_{21}$	$b_{54} = \frac{1}{2} a_{21}$	$b_{55} = a_{33}$

Figure: Group weights across NACE industries

back

- **Average quality:** Estimate price-adjusted quantities with country-product-year FE:

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = FE_{jkt} + e_{fjkt}$$

Standardize  $\ln \hat{\lambda}_{fjkt} = \hat{e}_{fjkt} / (\varepsilon_k - 1)$ :  $\Xi_{fjkt} = \frac{\ln \hat{\lambda}_{fjkt} - \overline{\ln \hat{\lambda}_{fjkt}}}{SE[\ln \hat{\lambda}_{fjkt}]}$

Regress results on firm FE:  $\Xi_{fjkt} = \widehat{Q1}_{ft} + \omega_{fjkt}$

- **Exports-weighted average quality:**

$$\widehat{Q2}_{ft} = \sum_{j,k} \frac{X_{fjkt}}{X_{ft}} \cdot \Xi_{fjkt}$$

- **Firm FE quality:** Estimate price-adjusted quantities with firm-year FE and country-product FE:

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = FE_{ft} + FE_{jk} + e_{fjkt}$$

Standardize firm FE:  $\widehat{Q3}_{ft} = \frac{FE_{ft} - \overline{FE}_{ft}}{SE[FE_{ft}]}$

back